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THE UNIVERSITY OF ALBERTA

A DIFFERENTIATED-RESOURCE VIEW OF READING SKILL

BY

JO-ANNE LEFEVRE

A THESIS

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Jo Anne LeFevre

Jo-Anne LeFevre
Department of Psychology
University of Winnipeg
Winnipeg, Manitoba
R3B 2E9

Date: April 2, 1988

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled A Differentiated-Resource View of Reading Skill submitted by Jo-Anne LeFevre in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

Supervisor

Date: 1988 February 12

DEDICATION

to my parents

FOR EVERYTHING

AND

to Chris

FOR

Conversations and jokes together, mutual rendering of good services, the reading together of sweetly phrased books, the sharing of nonsense and mutual attentions (St. Augustine, Confessions).

ABSTRACT

Reading has been characterized as resource limited: that is, all processes involved in reading are assumed to require cognitive resources from a single, undifferentiated source. In this view, individual differences in reading skill can be linked to the efficiency of resource use. These hypotheses were tested in two experiments. Resource requirements of reading familiar and unfamiliar texts were assessed using dual-task paradigms. In the first experiment, texts were presented in two forms: a standard paragraph presentation and a phrase-by-phrase condition. Subjects responded to auditory tones while reading as an index of available resources. The results did not support the use of the auditory tone task as an index of resource demands. Instead, differences between familiar and unfamiliar texts were reduced in the phrase presentation, suggesting that the tone task indexed interruptibility of processing. Furthermore, differences in the paragraph condition were found only for subjects who had inefficient working memory processes. In the second experiment, a more complex secondary task was used that required subjects to verify the presence of a word in a prior phrase. Differences in processing efficiency were related to verification latencies but familiarity of the text did not predict decrements in this dual task. An additional manipulation which involved interrupting reading with unrelated sentences was also not affected by the familiarity of the text. In support of the differences in processing familiar and unfamiliar texts, however, subjects spent longer at the ends of sentences while reading the unfamiliar material.

The results of these two studies are not consistent with a resource-limited view of reading, in which a single pool of resources is available to all processes. An alternative, differentiated-resource view is proposed, ~~in~~ which resources are associated with two components of the reading process (i.e., micro versus macroprocesses). The differentiated-resource view may ultimately prove useful for understanding the complex individual differences observed in the present studies.

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INTRODUCTION

Reading can be simplistically described as the transformation of written symbols into knowledge. However, in reality, reading is extremely complex and highly sensitive to subtle changes in the content and structure of text and to differences in the characteristics of the reader. The challenge faced by cognitive psychology is to account for both the simplicity and the complexity and to incorporate explanations of individual differences into general theories of reading.

One theoretical approach is to characterize reading as resource limited: All processes involved in reading are assumed to require cognitive resources from a finite source (Baddeley, 1986; Baddeley, Logie, Nimmo-Smith, & Brereton, 1985; Daneman & Carpenter, 1980; 1983; Just & Carpenter, 1980, 1987; Just & Thibadeau, 1984; Miller, 1984; Perfetti, 1985; Perfetti & Lesgold, 1977; Stanovich, 1980, 1981; Thibadeau, Just, & Carpenter, 1982; for exceptions, see Seidenberg, 1985; Spiro & Myers, 1984; Vipond, 1980). In this view, individual differences in reading skill can be ascribed to variability in processing efficiency, that is, the reading processes of less-skilled readers require more resources than those of skilled readers (Perfetti, 1985).

The resource metaphor has become a widely accepted vehicle for describing limitations in cognitive processing (Kahneman, 1973). According to Hasher and Zacks (1979), resource limitations are a "general limit on the energy available for performing mental operations" (p. 357). Operations are assumed to vary in the amount of energy they require and a reduction in the amount required is the

hallmark of skilled (efficient) performance. Resource requirements are also assumed to vary across individuals (Hasher & Zacks, 1979).

Models of Resource-limitations in Reading

Various implementations of the resource-limited view of reading have been proposed. For example, Perfetti (1985; Lesgold & Perfetti, 1978, 1981) has suggested that inefficient local or low-level processes reduce the resources that are available for comprehension (see also Just & Carpenter, 1980; Thibadeau, Just, & Carpenter, 1982; Underwood, 1985). A similar resource-limited model has been proposed by Stanovich (1980, 1981; Stanovich, Nathan, & Zolman, 1988; Stanovich, West, & Feeman, 1981). According to Stanovich, reading is an interactive-compensatory process in which resources made available by efficient processes at any level can be reallocated to compensate for limitations or inadequacies at any other level.

Daneman and Carpenter (1980, 1983) developed the reading span test to measure individual differences in processing efficiency. Reading span is based on the assumption that storage and processing operations require resources from the same pool (Baddeley, 1986; Baddeley & Hitch, 1974). Individuals with more efficient processes will have more resources for storing information than those with less efficient processes. In the reading span test, subjects read a series of sentences and are required to remember the last word of each sentence. As the number of sentences increases, fewer words can be remembered. Reading span is correlated with performance on standardized reading tests such as the Nelson-Denny (Dixon, LeFevre, & Twilley, in press; Masson & Miller, 1984) and with more specific measures of reading performance such as integrating information across

sentences (Daneman & Carpenter, 1980, 1983). These results are consistent with a resource-limited view of individual differences in reading skill. Skilled readers have more efficient reading processes and so can retain more words in the reading span test.

In general, a view of reading as resource-limited is appealing because it allows for (a) a theory of reading skill that is continuous across development, (b) an integrated theory of "normal" individual differences and of severe reading disability (Perfetti, 1985; Stanovich, 1986a), and (c) a theoretically motivated approach to reading remediation (Frederiksen, Warren, & Rosebery, 1985a, 1985b) and to reading instruction (Evans & Carr, 1985). In addition, the resource-limited view is parsimonious and consistent with general theories of processing limitations in cognition (Kahneman, 1973).

In this paper, two categories of evidence relevant to the resource-limited view are reviewed, (a) indirect evidence suggesting that older and more skilled readers have faster and more accurate lexical and segmentation processes than younger and less-skilled readers, (b) direct evidence from two sources; studies in which component processes were practiced or trained, and studies in which resource availability was assessed during reading. Two experiments are presented in which resource availability during reading was directly assessed and related to individual differences in processing efficiency and reading skill.

Evidence that Reading is Resource Limited

Understanding a written text involves a series of complex interactions among a variety of processes (Rumelhart, 1977). The potential complexity is reduced with a basic distinction between two

aspects of processing. First, microprocesses convert or translate the text into an internal representation. Kintsch and van Dijk (1978) described this representation as a "structured list of propositions" (p. 367), termed the text base. Propositions are conceptual units that are composed of a predicate and one or more arguments, linked together in the text base through referential coherence (i.e., argument overlap). Microprocesses that operate to construct the text base include letter encoding, lexical access, obligatory activation of related concepts through spreading activation (e.g., dog activates cat, as well as furry, four-legged etc.), syntactic processing and the activation of syntactic structures, propositional analysis and encoding, and anaphoric inferencing.

The second major component of reading, macroprocessing, involves the assembly of micropropositions and related information into a elaborated representation that can be used to answer questions, for recall, or for recognition performance. Macroprocessing includes inferences about the relationship between the information provided by the text and the reader's prior knowledge. Kintsch and van Dijk (1978) suggested that macroprocessing results in the creation of a mental structure that is distinct from the text base, but it is also plausible that the text base is simply elaborated. The most important aspect of macroprocessing is that world knowledge and the information provided by the text are linked together and incorporated into the mental representation. For the most part, researchers have focussed on inefficient microprocesses as sources both of individual and developmental differences in performance (i.e., Perfetti, 1985).

Indirect evidence for the resource-limited view: Microprocesses

Lexical processing. Younger or less-skilled readers have slower and less efficient word level processes than older or more skilled readers (for reviews see Carr, 1981; Golinkoff, 1975-76). In elementary school readers, these processes may include phonological processing, word encoding, lexical access, and use of sentence context to facilitate lexical access (e.g., Ehrlich, 1981; Hogaboam & Perfetti, 1978; Mann, 1986; Perfetti, Finger, & Hogaboam, 1978; Perfetti, Goldman, & Hogaboam, 1979; Perfetti & Hogaboam, 1975; Seidenberg, Bruck, Fornarolo, & Backman, 1985; Stanovich, Cunningham, & Feeman, 1984a, 1984b; Wolf, Bally, & Morris, 1986). It is clear that there are significant differences in reading performance that, in the early grades, can be linked to the basic skills required to process words (Mann, 1986; Stanovich, et al., 1984b). That is, young children need to develop efficient word-decoding mechanisms before their comprehension of text can approximate their comprehension of spoken language (Sticht & James, 1984).

Various studies have shown that adults may also differ in the efficiency of microprocesses, including lexical access (Baddeley et al., 1985; Dixon, et al., in press; Frederiksen, 1981, 1982; Graesser, Hoffman, & Clark, 1980; Jackson & McClelland, 1979; Palmer, McLeod, Hunt, & Davidson, 1985). For instance, high-school students who differed in reading skill (according to a standardized test) also differed in the speed and accuracy with which they encoded subword units and in the processing of pseudowords (Frederiksen, 1982). Jackson (1980; Jackson & McClelland, 1975) found that less-skilled readers had less efficient access to name codes in long-term memory

than skilled readers (where skill was defined as reading speed multiplied by comprehension). These results are consistent with the assumption that less-skilled readers have inefficient processes related to processing word level information. However, they are not proof that inefficient microprocesses cause differences in reading performance by using up valuable resources that, in skilled readers, are applied to comprehension. That is, it is not possible to make causal conclusions from data that are essentially correlational (Spiro & Myers, 1984; Stanovich, 1986a).

Stanovich (1986a) has suggested that differences among adults in lexical processes are not responsible for differences in comprehension. More generally, individual differences in microprocessing among adults may be "developmentally limited", in that "we may be tapping the mechanisms that earlier in their developmental histories led different individuals to diverge in the rates at which they acquired reading skill, but are not currently causing further variation in reading fluency" (p. 376). In this view, once the microprocesses have been acquired and are reasonably well-practiced, individual differences in comprehension skill may become distinct from individual differences in text-processing as reflected in microprocesses.

Segmentation processes. The process of creating units or propositions from text (see Kintsch & van Dijk, 1978, for discussion of propositional encoding) may also be limited by the availability of cognitive resources. The extent to which younger, less-skilled readers process text in units that are larger than single words is not clear. Younger readers and less-skilled readers may tend to read in a

word-by-word fashion (Cromer, 1970; Friedrich, Schadler, & Juola, 1979; Mann, 1986), whereas older, more skilled readers process information in phrases or multi-word groups (Aaronson & Scarborough, 1977; Cromer, 1970; Green, Mitchell, & Hammond, 1981; Jarvella, 1979; Kowal, O'Connell, O'Brien, & Bryant, 1975). However, children in grades three and five were found to be sensitive to the propositional structure of text (Keenan & Brown, 1984) and segmenting processes seem to improve with skill in the early grades (Dowhower, 1987).

If the processing of units (e.g., phrases or propositions) requires resources, then reduction of resource demands via segmentation of the text should increase comprehension by freeing up resources. Evidence from research with children is consistent with this view: For both skilled and less-skilled elementary school readers, segmenting the text improved comprehension (O'Shea & Sindelar, 1983; Weiss, 1983). Cromer (1970) also found that the comprehension performance of less-skilled adult readers (with adequate vocabularies) improved to the level of good comprehenders when text was segmented into meaningful units. (However, this finding was attributed to subject selection artifacts by Calfee, Arnold, and Drum [1976; cited in Spiro & Myers, 1984]).

Recent research with adults has suggested that segmenting may reduce the processing demands of reading for less-skilled readers. Chen (1986) used rapid serial visual presentation (RSVP) with adult subjects who had either small or large reading spans. Chen found that RSVP presentation of meaningful units of text improved the comprehension of subjects with small reading spans, such that they comprehended as well as subjects with large reading spans. RSVP

involves limiting the exposure duration of short units of text (e.g., single words or phrases) in order to eliminate eye movements and to control the length of time that a stimulus is available for processing (Potter, 1984). One interpretation of these results is that segmenting the text reduces the resource requirements associated with processing propositions for the subjects with small reading spans, thereby allowing additional resources to be devoted to comprehension (cf. Perfetti, 1985).

However, other research with adults is not consistent with the view that segmentation requires processing resources. Haberlandt and Graesser (1985) found no effect of the number of propositions in a sentence on reading times. Given the assumption than phrases roughly correspond to propositions and that segmenting text will require resources, then sentences with more propositions (i.e., more segments) would presumably require more time to process. Haberlandt and Graesser concluded that processing the segments in a sentence does not demand resources for skilled adult readers.

These somewhat contradictory findings about the processing demands associated with segmentation may be attributable to differences in procedure. Dividing the text into segments for the subject may have a number of consequences, not all of them directly related to the availability of processing resources. For example, text may generally be processed in units (i.e., phrases or propositions), but segmenting may not necessarily be a source of individual differences in resource availability. Instead, less-skilled readers may segment text inappropriately, producing units of poor quality. The result of providing segmentation may be to improve the quality of the segments

for the less-skilled readers, without differentially reducing resource requirements for skilled and less-skilled readers.

Summary. In summary, the indirect evidence from research concerned with lexical processing and segmentation suggests that individual and developmental differences can be described by a resource-limited view of the reading process. However, the evidence for resource availability as a source of individual differences in adult reading is primarily correlational and the observable microprocessing differences may not be causing differences in comprehension skill.

Direct evidence for the resource-limited view

Training studies. Research that involved training the component processes of reading is especially relevant to the resource-limited view of reading and provides the most direct test of this view because the evidence is causal. Improvements in the efficiency of component processes through training should result in a corresponding improvement in comprehension because more resources are made available to macroprocesses.

In young children, repeated readings of a text have been shown to improve both reading speed and comprehension (Dowhower, 1987; Herman, 1985; Leu, DeGroff, & Simons, 1986). However, studies in which word decoding was practiced until children could name words quickly and accurately have not shown corresponding improvements in comprehension (Fleisher, Jenkins, & Pany, 1975; Oaken, Wiener, & Cramer, 1971). In a recent study by Roth and Beck (1987), grade 4 children practiced word decoding skills using computer-based instruction across a school year. The trained students showed improvements in word decoding and

sentence level comprehension, but not on comprehension at the passage level. Further, only the students with very low initial scores showed any improvement with training. The skilled students did not benefit from the word-level decoding practice. The results of this study suggest that the resource-limited view applies to beginning readers, but may not characterize reading beyond a certain level of proficiency.

Frederiksen et al. (1985a, 1985b) implemented a large scale training program with adult poor readers. Three processing components were trained: encoding multi-letter subword units, decoding orthographic patterns, and context utilization. Frederiksen et al. (1985b) found some transfer to measures similar to the training tasks, and from the context utilization training to an inference test, but no transfer to a standardized comprehension test. Although there were large improvements in performance on the training tasks, the transfer gains were quite small, especially considering the extensive training required. In sum, extensive training of the microprocesses of children or adult poor readers seems to produce some limited improvement in the trained skills, with relatively little transfer to comprehension processes.

In contrast to the rather small effects of training microprocesses (at least for adults), Palincsar and Brown (1984) found that training of strategic and metacomprehension skills produced large significant comprehension gains (see also Dewitz, Carr, & Patberg, 1987; Paris & Oka, 1986). Palincsar and Brown trained poor readers in Grade 7 on study skills, including summarizing, questioning, clarifying, and predicting. These students, who met minimal standards for adequate

decoding, showed gains on various transfer tasks, including a standardized comprehension test. These results are consistent with a general model of resource-limitations in reading in which improvements in the efficiency of any process results in an overall improvement in performance (cf. Stanovich, 1980).

In summary, research on adult reading has produced little direct evidence that comprehension processes are resource limited. In addition, resource availability as a source of individual differences in skilled adult reading has not been directly assessed.

Dual-task studies. In a series of studies, Britton and his colleagues used a dual-task approach to examine the resource requirements of texts varying in content and structure (e.g., Britton, Graesser, Glynn, Hamilton, & Penland, 1983; Britton, Zeigler, & Wesbrook, 1980; Britton & Tesser, 1982; Britton, Wesbrook, & Holdredge, 1978). Britton's studies represent the only direct test of the resource-limited view that is available in the literature. In these studies, subjects responded to auditory tones while reading texts. It was assumed that the auditory probe and the reading task required resources from the same source (Kerr, 1973; Navon & Gopher, 1979; 1980; Norman & Bobrow, 1975). Therefore, response times to the auditory probe (the secondary task) presumably indexed the resource requirements of reading (the primary task).

The size of the decrements in the secondary task were expected to vary with manipulations that affect the resource requirements of reading. On the assumption that reading is resource limited, complex or difficult texts will require more effort to process during reading and therefore more resources than simple or easy texts (Kahneman,

1973). Britton has tested a variety of different manipulations of text to compare the resource requirements. However, as described below, the results of these studies are difficult to interpret.

Britton concluded that easy texts required more resources than difficult texts (Britton et al., 1978), that narratives required more resources than expositions (Britton et al., 1983), and that subjects with a large amount of prior knowledge had fewer resources available than subjects with a small amount of prior knowledge (Britton & Tesser, 1982). In all cases, reading the simpler texts resulted in larger decrements on the secondary task than reading the more complex texts. These results seem paradoxical, in that simple (e.g., easy) texts should presumably require fewer resources than complex (e.g., difficult) texts, regardless of the manipulation used to increase resource use. To account for these results, Britton proposed a cognitive contents hypothesis (Britton & Tesser, 1982). Easier, more familiar material was assumed to activate a large amount of related knowledge, schemas, and even associated words. Activation of this knowledge was assumed to require resources, leaving few available for processing the secondary task (Britton & Tesser, 1982).

However, the cognitive contents hypothesis only applies to semantic or content-related features of text. Britton, Glynn, Meyer, and Penland (1982) found that syntactically complex texts required more resources than syntactically simple texts. Similarily, Britton, Piha, Davis, and Wehausen (1978) found that the insertion of adjunct questions during reading decreased the resources available in that response times to the probe were slower when adjunct questions were present. Because the use of adjunct questions is thought to produce

greater learning, Britton et al. (1978) concluded that learning from text required resources.

It is evident that the cognitive contents explanation is not very satisfactory because the mechanism that is responsible for producing one outcome for macroprocessing and another outcome for microprocessing manipulations is not well-specified. It does not seem possible to consider the resource requirements of semantic and syntactic manipulations on an equivalent metric. Therefore, it is difficult to anticipate the results that would be expected from some other type of manipulation (e.g., variability in the complexity of technical material), or to predict individual differences within this framework.

A number of methodological limitations of Britton's work also make it difficult to evaluate his results. First, the text manipulations that he used were poorly controlled (with the exception of the syntactic manipulation used in Britton et al., 1982). For instance, easy texts in some studies were at a grade one level, whereas difficult texts were at a grade twelve level (Britton et al., 1978). Many aspects of these texts (both micro- and macrostructural) may have differed. Second, Britton did not assess decrements by controlling for single-task performance. Instead, he compared the secondary task latencies in the two text manipulations. Third, Britton did not assess potential decrements in the reading task. It may have been, for instance, that comprehension on the difficult texts decreased whereas comprehension on the easy texts did not change (as compared to a single-task measure). That finding could account for the increased latencies for the secondary task on easy texts.

There are a number of additional alternative explanations of Britton's findings. One possibility is that subjects may be processing the easy/simple and difficult/complex texts in differently sized units. That is, differences in secondary task latencies may indicate that the easy texts can be processed in larger units than more difficult texts (see Jarvella, 1979). With larger units, it may be harder to interrupt processing to respond to the auditory tone. In this view, longer latencies may reflect interruptibility, rather than available resources. In the present research, an attempt was made to rectify the methodological problems with Britton's studies and to assess some of the alternative explanations.

Overview of the present research

Two experiments were designed to test the hypotheses that (a) reading processes are resource limited and (b) resource limitations are a source of individual differences in reading skill. The availability of resources during reading was assessed with two dual-task paradigms. In both cases, the secondary tasks were assumed to require cognitive resources from the same source as the processes involved in reading. In order to assess performance tradeoffs, the processing demands of texts were manipulated. Familiar texts discussed well-known topics. Unfamiliar texts were very similar structurally, but discussed relatively unknown topics. If the cognitive contents hypothesis is correct, then response times to auditory probes should be slower while subjects are reading familiar than when they are reading unfamiliar texts. Conversely, if the resource-limited view is accurate, then response times to auditory probes should be slower when subjects are reading unfamiliar texts. Unfamiliar texts are

difficult to process and therefore should require more resources than familiar texts.

A familiarity manipulation was chosen because it was conceptually straightforward and because it represented a direct instantiation of the cognitive contents hypothesis (see Britton & Tesser, 1982). For example, one pair of passages used in the first study concerned Wayne Gretzky, a famous Canadian hockey player (familiar), and Wan Po Li, a famous Chinese Go player (unfamiliar, and in fact, fictional). The passages had the same number of sentences, a similar number of words, parallel sentence structures, and touched on very similar aspects of the lives of these two men. However, the passage about Gretzky was assumed to activate a large amount of related knowledge and associations that would not be activated by the Po Li passage (see Appendix 1a). Some pairs of passages were more similar than others, but all had the property that they were equally readable and comprehensible but varied in the familiarity of the topic (e.g., the same number of sentences, similar number of words, similar word length and word frequency, and similar or identical sentence structure).

In Experiment 1, the dual-task method used by Britton was combined with a text-format manipulation. Texts were presented in two ways: as a complete paragraph (Britton) or as short, meaningful units or "phrases". If the results found by Britton reflect the size of the unit of processing, then differential decrements as a function of familiarity will be found in the paragraph, but not the segmented presentation. A secondary goal of the contrast between paragraph and phrase presentation was to examine the effects of segmenting on reading performance. Segmenting the text was expected to reduce the

resource demands (especially for inefficient readers, e.g., Chen, 1986) and therefore comprehension should improve.

In the second experiment a different secondary task was used. McLeod (1978) found that obtained patterns of dual-task interference changed when the secondary task was modified. He suggested that the amount of overlap between the processes involved in the primary and secondary tasks would determine the pattern of performance tradeoffs, and hence the conclusions about the resource requirements of the primary task. In Experiment 2, texts were all presented in meaningful phrases. Periodically, after a phrase, a single word appeared. Subjects had to decide whether the word had appeared in the previous phrase. This verification decision constituted the secondary task. If the unfamiliar texts required more resources than the familiar texts, then the verification times during unfamiliar texts should be longer than during familiar texts. The prediction according to the cognitive contents hypothesis is that verification times should be slower during familiar texts because familiar texts activate more information and so require more resources than unfamiliar texts.

An additional manipulation was used in Experiment 2. After some sentences two unrelated factual statements appeared instead of the next sentence. Subjects were to read and try to remember these statements for later recognition. This interruption manipulation has been used by Glanzer and his colleagues (see Glanzer & Nolan, 1986) to disrupt processing of text. In Glanzer's research (e.g., Glanzer, Dorfman, & Kaplan, 1981), subjects spent longer reading the text that followed the interruption than they did reading text that had not been interrupted. The interruption is assumed to disrupt verbatim

information in short-term memory. The extra time after the interruption is used to reconstruct the information lost from short-term memory (e.g., for anaphoric references). On the assumption that this recovery process requires processing resources, the interruption effect should be larger for unfamiliar texts as those require more resources than familiar texts.

Finally, as part of Experiment 2, processing time was compared for phrases located in different parts of a sentence. Just and Carpenter (1980; see also Mitchell & Green, 1978) found that subjects spend extra time at the ends of sentences. This extra time is used for integrating the information in the sentence with the evolving representation of the text (i.e., macroprocessing). If unfamiliar texts require more resources, then the time spent at the end of a sentence should be greater for unfamiliar than for familiar texts.

Reading skill was assessed independently of the experimental tasks with a standardized reading comprehension test and a test of inferencing ability. In accord with Baddeley (1986), it was assumed that tradeoffs between the resource requirements of processing and storage can be used to index the efficiency of the requisite processes. Thus, individual differences in processing efficiency were measured with four different span measures (e.g., digit span) that varied in the amount they were assumed to overlap with processes related to reading. These individual difference factors were collected for each subject as part of a larger project, as described in the next section. Specific predictions about individual differences and their relations to reading performance are discussed after the individual difference measures are examined in more detail.

Assessing Individual Differences in Reading Skill

The cognitive contents hypothesis does not lend itself very obviously to predictions about individual differences in reading, as skilled readers are supposedly more efficient in their resource use and yet may be able to activate more relevant information than less-skilled readers. The resource-limited view is focused on efficiency: Skilled readers should have more available resources than less-skilled readers. To evaluate these predictions, two types of individual differences were assessed independently of the experimental tasks: reading skill (speed and comprehension) and processing efficiency. Reading skill was measured with (a) a standardized reading test, the Nelson-Denny Comprehension test (Brown, Bennett, & Hanna, 1981), that has a large speeded processing component (Masson, 1985), and (b) an inference test designed to measure the reader's ability to make plausible inferences based on world knowledge and a deep understanding of a text (Dixon et al., in press) that is mainly a measure of unspeeded comprehension.

Efficiency was measured in a number of different ways. The efficiency measures used included (a) a version of the reading span test developed by Daneman and Carpenter (1980) to index the resource requirements of reading by assessing storage/processing tradeoffs, (b) a standard digit span test (Dempster, 1981), (c) a running digit span test that has been described as a measure of processing efficiency (Rule & Dobbs, 1987), and (d) a probed word span test that is similar to tests described by Cohen (1982, see also Cohen & Netley, 1981; Waugh & Norman, 1965) designed to measure tradeoffs between processing

and storage of single words.

In a comprehensive review of the research on memory span, Dempster (1981) claimed that individual and developmental differences in span may reflect differences in processing efficiency. The assumption underlying the relationship between the span measures and efficiency is that more efficient processing will allow more information to be simultaneously stored, hence resulting in a larger "span". Tradeoffs between storage and processing functions are often referred to as "working memory" or "functional capacity" (Baddeley, 1986; Baddeley & Hitch, 1974; Baddeley et al., 1985; Daneman & Carpenter, 1980; 1983; Perfetti, 1985). However, in reading, research has shown that a standard measure of span (digit span or word span), is not related to reading performance (Daneman & Carpenter, 1980; Dixon et al., in press; Masson & Miller, 1984; Perfetti & Goldman, 1976). This finding is consistent with Daneman's claim that it is the efficiency of reading-specific processes that are important. In other words, a person with efficient reading processes would not necessarily have efficient arithmetic processes. Therefore, it was expected that reading span would be the best predictor of differences in reading performance that were due to efficiency.

Method

As part of another project, a large group of subjects were pretested on a variety of measures and a causal model of reading skill was developed (Dixon et al., in press). Subjects were selected randomly from this larger group to return and participate in two experiments. From the battery of tests, two types of test scores were selected that were relevant to the experimental hypotheses: efficiency

measures and reading skill measures as described below. Full details about all tasks used in the pretest are available in Dixon et al. (in press).

In the present research, the focus was on the efficiency of reading because the theories being evaluated concern the use of cognitive resources. Specifically, efficient use of cognitive resources is predicted to result in good reading comprehension (Perfetti, 1985). In addition to the efficiency measures administered as part of the pretest, two additional tests were given as part of Experiments 1 and 2. These are also discussed below. The time of administration (pretest or experiment) of each measure is indicated beside it in parentheses.

Subjects

A total of 95 undergraduate volunteers participated in the pretest. Sixty-three were female, 32 male. Forty of these subjects returned and completed the running digit span and reading span tests as part of their participation in the experimental tasks.

Instruments and Procedure.

Digit Span (Pretest). On each trial, subjects listened to a string of digits from the set of single digits 1 through 9. After hearing the digits, the subjects were required to write them down in the order that they had been presented. Two trials were presented at each string length from 4 to 9. The string lengths were presented in increasing order. The digits were presented via a tape recorder at the rate of 1 per second. For scoring purposes, one point was awarded for each correct digit in a correct position, relative to the originally presented positions. Maximum possible score was therefore

98. According to Dempster (1981), the digit span test assesses the speed of item identification in short-term memory and so may reflect differences in the efficiency of basic information processing. Others have proposed that traditional span tests index the storage capacity of short-term memory, whereas span tests that have greater transformational requirements will index both storage and processing demands (Baddeley, 1986; Daneman & Carpenter, 1981, 1983).

Running Digit Span (Experiment 1). This task was developed by Rule and Dobbs (1987; see also Kirchner, 1958) to examine changes in processing efficiency that occur as a function of age. It is a combination of a memory task and an online processing task. In the running digit span task, subjects are required to listen to single digits (from 1 through 9) presented via a tape recorder at the rate of 1.8 per second and repeat back the digits under four difficulty levels. At the simplest level, subjects repeat back the digits immediately, that is, as soon as they hear each digit they echo it. At the second level of difficulty, they hear two numbers before they respond with the first digit. After they hear the third digit, they respond with the second digit, and so on. At the third level of difficulty, subjects respond with the digit that came two times before the one just presented. And at the fourth level of difficulty, they respond with the digit presented three times before the current one. The running digit span test was presented individually to each subject. Responses were scored by giving credit for the number of digits correctly reproduced until an error was made. No credit was given for correct digits that occurred after an error. Two trials of ten digits each were given at each difficulty level for a total

possible score of 80.

The running digit span task requires storage, as well as online processing, updating, and outputting of information. Performance on this task has been shown to decline with age (see Rule & Dobbs, 1987; Kirchner, 1958), presumably due to decreased efficiency of processing.

Probed Word Span (Pretest). This probed word span task was designed to be administered in groups. It was modelled after the running digit span test described above in that it required both storage and manipulation of information in short-term memory (see also Cohen & Netley, 1981). In the probed word span test, a series of words was presented auditorily and at the end of the series a tone was presented. When subjects heard the tone, they were to recall the third-last word of the series. Because the lengths of the presented word series were variable, the subject had to store the incoming words and update them as the new words were presented. It was assumed therefore that, like running digit span, probed word span assessed aspects both of storage and processing. Series ranged in length from 3 to 8 words, with 3 sets at each length, for a total of 18 trials. Words were presented auditorily, at the rate of 1 every 1.33 seconds. The words used were all one syllable in length and were selected to minimize associative relationships (see Appendix 5).

Reading Span (Pretest and Experiment 2). The reading span test was first developed by Daneman (Daneman & Carpenter, 1980, 1983) and has subsequently been used by other investigators to examine the role of working memory in reading (Baddeley et al., 1985; Dixon et al., in press; Masson & Miller, 1983). The reading span test taps both storage and processing functions (Baddeley, 1986; Baddeley et al., 1985;

Daneman & Carpenter, 1981, 1983). In the specific version of the task used in the present research, subjects read sentences and were required to decide if each made sense or was nonsensical (for example, "The angry pillows ate the bad idea" was nonsensical). The complete set of sentences is shown in Appendix 5. After reading and evaluating each sentence in a set, subjects recalled the last word of each sentence. The more efficient a subject's reading processes, the more resources should have been available for storing the words. This view is consistent with Baddeley's conception of the role of working memory in reading (see Baddeley, 1986). The reading span test was assumed to index the efficiency of reading-specific processes (Daneman & Carpenter, 1981, 1983; Daneman & Green, 1986).

The first administration of the reading span test was part of the pretest, in which the sentences were presented via a slide projector. Three sets of sentences were presented at each set length of 2, 3, 4, and 5 sentences per set. Each sentence was presented for six seconds. Subjects made an immediate sense/nonsense decision. After all the sentences in a set were presented, the word "RECALL" appeared, and the subjects were given 11 seconds to write down the last word of each sentence. As part of Experiment 2, this test was re-administered to each subject individually, with the sentences presented on a computer screen. The same procedure was used, except that subjects had unlimited time to write down the last words in the sentences. The second presentation of the test was identical to the first, except that 3 sets of 6 sentences were also presented. It was of interest to examine the test-retest reliability of the reading span measure. Further, the sixth set was added because of some concern that a set of

length five does not represent the upper limit of performance for many of these subjects, many of whom fall into the range of average to excellent readers.

Three different measures are presented for the reading span test: the original score from the pretest administration (old reading span 5), the score of the first 42 sentences as part of the experimental administration (new reading span 5), and the score from the complete set of 60 sentences as part of the second administration. For the analyses of the experimental items, the latter score was used.

Nelson-Denny Comprehension (Form F, Brown et al., 1981; Pretest). This test is made up of short expository paragraphs accompanied by multiple choice questions. Subjects were given 20 minutes to answer a total of 36 questions. Some of the questions had answers that are available from the surface structure of the text, whereas others required inferences. The Nelson-Denny seems to be highly weighted in favour of subjects who read quickly, because it is time-limited (Masson, 1985; Palmer et al., 1985). According to the instructor's handbook (Brown et al., 1981) only one in three people taking the test are expected to finish.

Inference Test (Pretest). This test was developed to assess "deep" comprehension. Subjects were required to answer questions after reading a passage that required inferences be made with the information gleaned during reading. None of the answers to the questions were available from the surface structure of the text, unlike the Nelson-Denny questions which tend to assess superficial facts or anaphoric reference (the inference test is given in Appendix 4). The inference test requires subjects to remember events that were

mentioned in the story and assemble information in working memory using similar skills to those required for the inferencing that occurs during reading. Unlimited time was given for answering the questions.

Results and Discussion

The purpose of collecting the individual difference data was to assess processing efficiency and reading skill in order to relate these to performance on the experimental tasks. Subjects with efficient processes were expected to be good readers (Baddeley et al., 1985; Daneman & Carpenter, 1980, 1983; Perfetti, 1985).

Characteristics of the sample

The group of subjects who participated in the present study were selected randomly from the pretest group. In general, the mean and standard deviation of the Experiment 1 sample on each of the individual difference measures was very similar to that of the (larger) pretest group, as shown in Table 1. The range of scores for each measure was also quite similar, with all but the Inference and Vocabulary tests capturing the complete range of scores. As shown in Table 2, the pattern of significant correlations was identical for the sample and the pretest groups, and the magnitude of the correlations was also comparable. Thus, the sample of subjects who participated in Experiment 1 was representative of the pretest group, and so the conclusions made by Dixon et al. (in press) about the interrelationships among the measures should also apply to the present sample.

Of particular interest are the interrelationships among the various efficiency measures. The traditional digit span measure was significantly correlated with all the other span measures. Individual

differences in digit span performance have been ascribed to item processing speed and to the ability to retain serial order (Dempster, 1981). The other span measures were only moderately related to one another, however, and these correlations can be accounted for by joint relations to digit span (memory capacity). This result suggests that the various span measures are influenced by the efficiency of sets of processes that show little overlap. For example, Daneman has claimed that reading span assesses the efficiency of processes specific to reading. Similarily, the running digit span test may tap the efficiency of processes involved in manipulating continuous strings of unrelated information. Probed word span may assess yet another aspect of processing that is related to retrieving a particular word from a verbatim short-term store. In other words, it may not be possible to use a single test to measure processing efficiency: Efficiency may be relevant only for those particular processes used in the task of interest.

The correlation between the two reading skill measures, Nelson-Denny and inference, was small and insignificant. As suggested by Dixon et al. (in press), these two measures index separate aspects of reading skill. The Nelson-Denny is speeded and so probably is heavily influenced by microprocessing, whereas the inference test is unspeeded and does not require knowledge about the surface structure of the text to the same extent as some questions on the Nelson-Denny.

Significant relations were expected between the efficiency and the skill measures, on the assumption that the efficiency measures require the same processes as are involved in reading. In the Experiment 1 sample, only the original reading span measure was

correlated with Nelson-Denny score. Both the original reading span and the new reading span measures were related to inference test score, but running digit span and probed word span were not. As suggested by Daneman (Daneman, 1984), the span measure that is most closely related to the processes involved in reading shows the greatest overlap with reading skill.

Reliabilities

The reliability of the Nelson-Denny test is reported as .77 (Brown, et al., 1981). No reliability measure was available for the inference test, however, the correlation between the score on the first story and the score on the second story (see Appendix 4) was .31 (n=95). No reliability measures were available for running digit span, standard digit span, or probed word span.

The test-retest reliability of reading span was of interest as performance on this test has not been compared at two widely separated times. The mean and standard deviations of the measure at the two administration times was extremely consistent and the correlation between the scores for the first and second administrations was .60 for the Experiment 1 sample. This moderate level of reliability is reasonable, given the widely separated test times (approximately 7 to 9 months) and the minor procedural differences between the two administrations (i.e., group vs. individual testing, slide vs. computer presentation, 11 seconds vs. unlimited time to record the last words). However, it was disturbing that the pattern of significant correlations between reading span and the other skill measures changed from one test time to the other. Unlike the reading span measure collected at pretest, the second administration of the

test was not significantly related to Nelson-Denny comprehension and only marginally related to vocabulary. The low correlations with comprehension were especially surprising in light of previous research indicating substantial relationships between reading span and comprehension (Baddeley et al., 1985; Daneman & Carpenter, 1980, 1983; Dixon et al., in press; Masson & Miller, 1983).

In contrast, the correlations between the new reading span test and the other efficiency measures (i.e., digit span, probed word span) and to the inference test were quite consistent. A hierarchical regression analysis of the three measures of reading span for the Experiment 1 sample is shown in Table 3. It is evident that the traditional digit span test accounts for most of the correlation between reading span and the other span measures. Based on this analysis, the following assumptions were made. Reading span was assumed to assess the efficiency of processes that are specific to reading, including, for example, lexical access, syntactic processing, and propositional encoding (see Daneman, 1984; Perfetti, 1985). Probed word span was assumed to index the efficiency of a more specific set of processes, that is, word access and recall from short-term memory. In contrast, running digit span was assumed to reflect the efficiency of manipulating information in short-term memory or the flexibility of using cognitive resources (R. G. Heller, personal communication, December 4, 1987).

In the two experiments that follow, all three efficiency measures and both skill measures were used as individual difference variables. According to a resource-limited view of reading, performance should be better for skilled as compared to less-skilled readers because the

former have more efficient reading processes. Skilled readers may read text faster than less-skilled readers, they may comprehend the text better, and they may also show smaller decrements in dual-task latencies. The decrements will be a direct reflection of available resources or efficiency. The individual differences in efficiency (at least as indexed by reading span) were also expected to be related to performance.

EXPERIMENT 1

In Experiment 1, dual-task methodology was used to assess the resource requirements of reading expository text (Kerr, 1973; Navon & Gopher, 1979, 1980; Norman & Bobrow, 1975). In the dual-task approach, performance on a secondary task is used to index the resource requirements of a primary task (i.e., reading). The goals of this study were to (a) evaluate the hypothesis that reading is resource limited by assessing the resource requirements of familiar versus unfamiliar texts, and (b) relate resource availability to individual differences in reading performance.

According to the cognitive contents hypothesis proposed by Britton (e.g., Britton & Tesser, 1982), familiar texts will activate a large amount of related information and should therefore require more resources than unfamiliar texts (Britton & Tesser, 1982). An alternative possibility is that familiar texts can be processed in larger units and are therefore less easily interrupted than unfamiliar texts. To test this hypothesis, texts were presented in both a standard paragraph presentation and in a phrase presentation. By controlling the size of the processing units, any difference between familiar and unfamiliar texts should be eliminated. Individual differences in efficiency and reading skill were also examined in relation to performance in the dual-task paradigm. More efficient readers were expected to show less of a decrement from the single to the dual-task because they presumably have more available resources.

The dual-task methodology used in the present study was very similar to that used by Britton (Britton et al., 1982; 1983; 1979; 1978; 1980; Britton & Tesser, 1982). Subjects were required to respond

to auditory tones while reading expository texts. If the amount of time required to respond to the tone is assumed to index available resources, then reading tasks that require more resources should result in slower response times to the tone.

There were three major differences between the present study and the research done by Britton and his colleagues. First, measures of single-task performance in both the reading and the tone tasks were collected. In general, Britton has reported tone-task performance and has not considered the possibility that reading performance may have declined relative to a single-task reading situation. This could compromise interpretation of the secondary task results if more resources were allocated to the secondary task in the dual- than in the single-task situation, such that the secondary task performance was not an accurate measure of the actual resource demands of reading.

Second, two different presentation formats were used, paragraph presentation and phrase presentation. The paragraph presentation was essentially equivalent to the presentation format used by Britton, although the text in the present study was displayed on a computer screen instead of on paper. In the phrase presentation, the text was segmented into meaningful units averaging four words in length and each phrase was presented separately. Subjects pressed a button to advance to the next phrase.

The third difference between the present study and those done by Britton was the nature of the text manipulation. Many of the text manipulations that have been used by Britton were inadequately precise. For instance, in Britton et al. (1978), easy texts were at the first and second grade level, whereas hard texts were at the

college level. Any number of factors could have differed between these texts in addition to prior knowledge, such as syntactic complexity, word familiarity, sentence length, and so on. In the present study, texts were constructed to vary primarily in the familiarity of the topic, while holding other factors such as sentence structure, complexity, and comprehensibility reasonably constant.

In Experiment 1, the following specific predictions were tested. First, according to Britton, familiar texts should require more cognitive resources than unfamiliar texts, and so responses to the probes should be slower when subjects are reading familiar texts. This result would be supportive of the cognitive contents hypothesis (Britton & Tesser, 1982). However, an alternative explanation for this result is that the dual-task technique used in the paragraph presentation assesses size of processing units rather than available resources. That is, processing of the tone may have to be deferred until a processing boundary is reached (Jarvella, 1979). If the assumption is made that familiar texts will be processed in larger units, then the difference in response times between familiar and unfamiliar texts may reflect the size of the processing unit. When the size of the unit is controlled, as in the phrase presentation, then the familiarity effect should disappear. Furthermore, if the processing units hypothesis is correct, and if skilled subjects process text in larger units, then differences in probe latencies between skilled and less-skilled readers should decrease in the phrase presentation.

Method

Subjects

Subjects from the pretest group were randomly selected and asked to participate. Of those asked, three refused to participate. Others did not show up for their scheduled appointments, and were either rescheduled, or new subjects were contacted to replace them. A total of 40 subjects participated in Experiment 1. Subjects were paid for participation. The first 24 subjects who participated returned at a later date to participate in Experiment 2.

Materials

Pairs of passages were constructed that varied primarily in the familiarity of the topic (see Appendix 1a). The goal of passage construction was to create pairs of texts of comparable difficulty, complexity and so on, that would vary in the amount of prior knowledge available to the subject. Pilot testing was used to verify the familiarity manipulation. Initially, ten pairs of passages were constructed, and undergraduate students were asked to rate the familiarity of the topics of the passages on a nine point scale where one was completely unfamiliar and nine was very familiar. Subjects also answered multiple choice questions about each text. For those pairs that did not show a significant difference in rated familiarity, one of the pair was replaced, and the pilot testing repeated.

The final set of eight pairs differed significantly in mean familiarity rating (familiar 5.76, unfamiliar 1.96), $t(14) = 13.6$, $p < .01$. (See Appendix 2 for the familiarity ratings for each passage). Each pair of passages had the same number of sentences, a very similar number of words (familiar, mean of 219, vs. unfamiliar, mean of 215,

$t(14) = .23$, as shown in Appendix 2). In addition, the actual words and phrases that were used overlapped considerably between the familiar and unfamiliar passage in a pair (see Appendix 1a). Four practice passages of similar lengths and style were selected from a set of expository texts taken from magazine articles.

For each experimental passage, five multiple choice questions were selected from among those used in the pilot study, such that the average score of the pilot subjects was about 60% correct on each question. Five questions were also written for each practice passage.

Each passage was divided into segments of one to seven words in length. Each segment was intended to be an "idea unit", designed to preserve linguistic and semantic boundaries (Cocklin, Ward, Chen, & Juola, 1984; see also Cromer, 1970; O'Shea & Sindelar, 1983). Cocklin et al. (1984) found that comprehension was better for texts divided into idea units as opposed to arbitrary groups of approximately the same number of words (using RSVP presentation). In the present study, segments were created at obvious boundaries (such as after commas and periods), to produce phrases averaging four words in length. Adjectives were kept with the nouns they modified, for example, and verbs with their subjects, when possible.

Design

For the reading task, eight conditions were defined by crossing the factors of Task (Single or Dual) x Presentation (Paragraph or Phrase) x familiarity (Familiar or Unfamiliar). Subjects also responded to tones alone (single-task tone condition). All subjects participated in all nine conditions. Within blocks of eight subjects, the experimental passages were randomly assigned to conditions, with

the constraint that each passage appeared once in each of the eight reading conditions. The materials were ordered such that, within each block, half the subjects had the dual-task conditions before the single-task, and within each task condition half had paragraphs then phrases, and half the reverse, with single-task tones always following single-task reading.

Apparatus

An Apple II computer was used to control presentation of the tones and the text and to record response and reading times. Times were accurate to the nearest millisecond.

Procedure

Running digit span. The running digit span text was administered using the standard instructions (Rule & Dobbs, 1987). Total test time was approximately 15 minutes.

Single task: tone response. For all experimental tasks, a button box with two buttons on it was used. Subjects held the button box in both hands and used their thumbs to press the buttons. Subjects were instructed to hold down the button marked 'T' (for tone) with their left thumb. The other button, marked 'S', was used to initiate a trial. During each trial, the message 'TRIAL X' (where X was the trial number) appeared alone on the screen. Subjects waited until either a tone was given or the trial ended. If a tone occurred, they were to release the T button as quickly as possible. Task instructions stressed the importance of speed. Tones were given on approximately 50% of the trials and tone trials were randomly determined for each subject. The delay between the start of the trial and the occurence of a probe varied from 1 to 5 seconds. If no probe occurred after 5

seconds, then the trial ended. Testing continued until 20 successful tone trials had occurred, where successful means that subjects did not release the button before the tone occurred. The total number of trials for each subject varied from 35 to 60.

Single task: reading. Two different reading presentations were used. In the paragraph presentation, the complete passage appeared on the computer screen when the subject pressed the S button. The first line was indented 5 spaces, with all subsequent lines appearing flush with the left edge of the screen and the right ranging. The text was single-spaced and the maximum line length was 80 characters. A maximum of 24 lines could be shown on the screen but the actual number of lines depended on the length of the passage. Pressing the S button terminated the passage presentation. In the phrase presentation, the passage was presented one phrase at a time. Pressing the S button caused the current phrase to be replaced by the next phrase. Each phrase appeared in the vertical centre of the screen, flush to the left edge. Between displays there was a blank interval of 17 ms.

Dual task. In both of the dual-task conditions, subjects held down the T button, releasing it when they heard a tone. In the paragraph presentation, tone trials were randomly determined. Tones occurred at least 10 seconds apart, and the maximum number of tones in a passage was 10. In the phrase presentation, the location of the tones in the passage was predetermined (randomly across passages but the same for each passage in a familiar/unfamiliar pair). Tones occurred 100 ms after the onset of the phrase. This relatively brief stimulus onset asynchrony (SOA) was chosen because of the expectation that some subjects would read the shorter phrases extremely rapidly. Within

pairs of passages (i.e., familiar and unfamiliar), the tones occurred at approximately the same location, that is, in the same sentence and in the equivalent phrase. The assignment of phrases and tone locations are shown for each passage in Appendix 1a (familiar and unfamiliar pairs of passages appear contiguously).

Practice. Each subject was given practice in the single-task tone condition (5 tone trials), the dual task paragraph condition (1 short passage), and the dual task phrase condition (1 short passage), accompanied by verbal instructions from the experimenter. Any questions the subject had were answered. The practice sets insured that the subjects understood the task and became familiar with the workings of the button box.

After reading each passage, subjects indicated their familiarity with the topic of the passage and marked it on a nine point scale provided in the instruction booklet. Next, they answered multiple choice questions that were shown on the computer screen, marking the answers in the booklet. Finally, they made up a title for the passage. The purpose of the title task was to encourage interpretative processing of the text over memorization.

The 16 subjects who did not participate in Experiment 2 also completed the reading span test (as described in the Individual Differences section) after finishing the experimental task. The subjects who did participate in Experiment 2 were given the reading span test at the beginning of the second session. Total time to complete this study varied from 1.5 to 2 hours.

Results and Discussion

Analyses

For each dependent measure (probe response time, multiple choice comprehension score, and reading speed), an analysis of variance was done with the appropriate factors. Subsequently, the individual difference variables were included in a regression analysis. Regression analyses were used both to determine the role of the individual difference factors and to assess dual-task decrements.

A regression analysis involving both between- and within-subjects factors involves two steps (Cohen & Cohen, 1983). First, the mean for each subject (collapsing across within-subject factors) is analyzed in a multiple regression that includes only the between-subject factors. In the present analyses, the between-subject factors included single-task performance, as well as the individual-difference scores. Second, another regression analysis is done using all the data, and including the within-subject factors such as familiarity and presentation format. Interactions between the between- and within-subject factors are added after all the main effects have been included and the increment in variance accounted for is examined. The error term for the within-subject main effects and interactions is adjusted to reflect only that variance not accounted for by subjects, as is done in the typical repeated-measures analysis of variance (Cohen & Cohen, 1983).

In order to simplify the discussion of the individual difference factors, the mean of each variable was subtracted from each subject's score on that variable. (This procedure is known as centering.) When all of the independent variables in the analysis are centered, then

the regression coefficient for each variable represents the size of effect of that variable, given all other variables are held constant at their mean. Centering also reduces the multicollinearity that can occur with interactions that are the product of two variables (Cohen & Cohen, 1983). In addition, centering means that the regression constant is conceptually equivalent to a grand mean in an analysis of variance.

In the discussion of the individual difference factors, "high" and "low" skill or efficiency refer respectively to plus and minus one standard deviation from the mean of that factor. Thus, high and low skill or efficiency are defined relative to the present sample.

Probe Response Times

Response times to the auditory probe in the dual-task condition were initially analyzed with the factors of Order (Dual-single vs. Single-dual), Presentation (Paragraph vs. Phrase), and Familiarity (Familiar vs. Unfamiliar), with repeated measures on the last two factors. The results did not replicate those of Britton: There was no significant difference in probe response times for familiar versus unfamiliar texts (394 vs. 390 ms), $F(1,38) < 1$. The only significant effect was that response times to the probe were slower in the phrase presentation than in the paragraph presentation (418 vs. 366 ms), $F(1,38) = 43.59$, $p < .001$. This difference probably reflects task complexity and/or response competition in the phrase condition. That is, subjects had to press two buttons during reading in the phrase condition, whereas in the paragraph condition they had only to press the tone response button while reading.

In the regression analyses of probe response times the single-task

probe response time was included first as a predictor before examining the contribution of other factors, which is equivalent to using a difference or decrement score (Cohen & Cohen, 1983). This procedure yields a more powerful test, however, because with difference scores, the variances of each variable are additive (Cohen & Cohen, 1983). Individual differences in processing efficiency were represented by running digit span, reading span, and probed word span, and reading skill was represented by Nelson-Denny and Inference test scores. Within-subject factors included familiarity, presentation format, and the interaction of familiarity and presentation format with each of the between-subject factors.

The results of the regression analysis are shown in Table 4. The increment in variance accounted for by each variable is shown as the hierarchical R^2. The semi-partial R^2 is the percentage of variance accounted for by that variable after all other variables have been accounted for (i.e., as if it were added last). The t value that is shown is the significance of the coefficient and of the semi-partial R^2. Note that, because single-task performance was partialled first, all other changes in R^2 represent decrements controlling for single-task probe response times. The single-task baseline measure accounted for a significant percentage of the variance in dual-task performance. Subjects were slower in the dual- than in the single- task condition (overall means in each condition of 392 vs. 317 ms). None of the individual difference measures significantly predicted decrements in dual-task latency.

Subjects responded to the auditory tone more quickly in the paragraph than in the phrase presentation (189 vs. 243 ms decrements).

According to the dual-task assumptions, therefore, the phrase presentation required more resources than the paragraph presentation. However, the phrase presentation was complicated by the need to deal with two buttons while reading and therefore may require different processes than are used in the paragraph presentation.

Familiarity did not significantly predict decrements, and there were no significant two-way interactions between familiarity and the individual differences measures.

Presentation format interacted with Nelson-Denny score, as shown in Table 5. Decrements in the phrase condition were equal for skilled and less-skilled readers. However, readers with high Nelson-Denny scores had smaller decrements in the paragraph condition than those with low scores, suggesting that fewer resources were required by the skilled readers in the paragraph condition. This result is consistent with the hypothesis that skilled readers are more efficient information processors. However, the lack of a difference in the phrase presentation indicates that the efficiency being assessed may be related to reading characteristics that are equated for the two groups by phrase presentation. In other words, consistent with Cromer (1970), phrase presentation may reduce processing demands for the less-skilled subjects.

There was also a significant three-way interaction between familiarity, presentation format, and running digit span as shown in Table 6. Subjects with small running digit spans showed a familiarity effect consistent with the cognitive contents hypothesis in the paragraph presentation: larger decrements while reading familiar than unfamiliar texts. Subjects with high running digit spans and both

groups in the phrase condition did not show this effect.

The significant interaction between familiarity, presentation, and reading span is shown in Table 7. Recall that reading span is assumed to index the efficiency of reading processes. Evidently, the efficiency measured by reading span is different from that measured by running digit span. Subjects with large reading spans showed an effect consistent with the cognitive contents hypothesis in paragraph condition, an effect similar to that shown by subjects with small running digit spans.

One explanation is that efficient readers (i.e., those with large reading spans) have fewer resources available in the paragraph condition than less efficient readers. This explanation seems unlikely however, as it is inconsistent with theories of resource-limitations in reading. An alternative explanation is that efficient readers process the text in larger units. Because the familiarity effect is attenuated in the phrase condition, the latter explanation seems most reasonable. This interpretation as applied to the running digit span interaction suggests that subjects with small running digit spans process texts in larger units than those with large running digit spans. In other words, the correlation between reading span and running digit span does not seem to represent the same type of efficiency.

The size of the processing unit seems like a reasonable account of the present results as well as those obtained by Britton. Easy, familiar texts, those with titles, and those with simple syntax can be processed in larger units than difficult, unfamiliar texts, those without titles, and those with complex syntax. These effects are most

noticeable for subjects who process text in large units anyway (large reading span and small running digit span). Presenting the text in phrases eliminates the difference.

Clearly, these results do not support the assumption that the auditory probe task measures resource use during reading in a straightforward way. It seems more likely that this task assesses how easily processing can be interrupted, perhaps on a very basic level. For instance, people have been found to fixate less often on texts that are easy to comprehend (Buswell, 1937) and when they are reading more quickly (Just & Carpenter, 1987). Thus, when a probe tone occurs on an easy text, an eye movement is more likely to be in progress and this motor task may be susceptible to interference.[1] By using computer presentation, which subjects found relatively novel and therefore difficult, any eye movement difference between familiar and unfamiliar texts may have been disrupted, and therefore there was no main effect of familiarity. Only those subjects who process text in large units anyway continued to show the effect.

There are a number of other possible reasons why the present research did not replicate Britton's results. One possibility is that insufficient power was available to detect an effect. To assess power, an average effect size was calculated from the most similar studies reported by Britton: easy versus hard texts (Britton et al., 1979; Britton et al., 1980), narrative versus expository texts (experiment 1-4, Britton et al., 1983), and high versus low prior knowledge (experiment 1, Britton & Tesser, 1982). The average effect size was 31, with a range from 17 to 57. Power was calculated to be

1. This explanation was suggested to the author by Dr. Michael Dawson.

greater than .85 for detecting an effect of 30 ms, so it is likely that the design was sufficiently powerful (Kirk, 1968).

A second possibility is that the familiarity manipulation may have been a weak manipulation of difficulty, in that familiarity is a relatively subjective and variable characteristic of a text. To evaluate this possibility, subjects were asked to rate how familiar they were with the topic of each text after they were finished reading it. The correlations between familiarity and rated familiarity were .59 and .73 for the paragraph and phrase presentations respectively, $ts > 6.52$, $ps < .01$. Examination of the mean ratings for each passage indicated that three familiar passages in the paragraph condition and one in the phrase condition were rated lower in familiarity than they had been in pilot testing. One of the unfamiliar texts was rated more familiar than in pilot testing in both the paragraph and the phrase condition (see Appendix 2). Thus, the familiarity manipulation was relatively consistent across passages and across subjects.

A related possibility is that the familiarity manipulation used in the present study was not a good instantiation of a "prior knowledge" manipulation, as discussed by Britton and Tesser (1982). According to their description, if a large amount of prior knowledge is available for a given text, then activation of this knowledge will require large amounts of the available resources, reducing the amount available to respond to the secondary task. For the familiarity manipulation, if we compare the Gretzky text (#107) to the Wan Po Li text (#108), it seems evident that subjects will have a larger amount of related knowledge and experience about Gretzky that they can activate than they will about a fictional Go player. Therefore, it seems reasonable to assume

that the familiarity manipulation provides an adequate test of the cognitive contents explanation.

There are, of course, a number of differences between the present research and that of Britton and his colleagues. One major difference is the way that prior knowledge was manipulated. In the various papers by Britton in which prior knowledge was manipulated it was confounded with the meaningfulness of the text. For example, in Britton and Tesser (1982; Experiment 1), the critical text was a page from the centre of a novel. The subjects in the high prior knowledge condition read the two pages that preceded the critical page in the novel before being tested on the critical page, and subjects in the low prior knowledge condition read two unrelated pages from the same novel. It could be argued that both of these conditions represented relatively low knowledge states, in that neither group had read the preceding half of the novel. The high prior knowledge group may have found the critical page somewhat more meaningful, in that they had at least a vague idea of the flow of the story. Similarily, in an earlier study (Britton, Holdredge, Curry, & Wesbrook, 1979), paragraphs were used that had little intrinsic meaning without the presence of a title (e.g., the washing clothes paragraph originally used by Bransford & Johnson, 1973). Again, the paragraphs in the high prior knowledge condition (i.e., with title) would be more meaningful to the subjects. Thus, in these studies, the amount of prior knowledge was confounded with whether the text made sense. Subjects may have stopped trying to interpret the texts that were not meaningful and would therefore be less involved in processing the text when a probe occurred.

In the present study, the assumption was that the familiar and

unfamiliar texts were equally comprehensible, but that the familiar texts were about topics that the subjects had read or thought about in the past. None of Britton's manipulations of prior knowledge (at least in the reading tasks he used) varied prior knowledge as directly, while holding meaningfulness relatively constant.

The second major difference between the present study and Britton's research was that single-task measures were collected for both the primary and secondary tasks. In some of Britton's studies, single-task probe times have been collected (see Britton & Tesser, 1982, Experiment 2), but single-task reading performance was not usually assessed. Therefore, those studies are open to the criticism that performance on the primary task may not have been maintained in the dual task. In the present study, single-task reading performance was assessed both with reading times and with comprehension scores. Two issues were of particular interest (a) do speed and comprehension change from single- to dual-task conditions, and (b) what is the effect of segmenting text on speed and comprehension. It has been suggested that one effect of segmenting text might be to increase comprehension, at least for less-skilled, or less-efficient readers (Chen, 1986; Cromer, 1970).

Reading Speed

The time required to read each passage was converted to a speed score in words per minute (wpm) and analyzed in a 2(order) by 2(task) by 2(presentation format) by 2(familiarity) analysis of variance, with repeated measures on the last three factors. According to the cognitive contents hypothesis, the familiar texts should be read more slowly than the unfamiliar texts because the large amount of activated

information should slow processing (Britton & Tesser, 1982). In fact, the results indicated that the familiar texts were read more quickly than the unfamiliar texts (186 vs. 168 wpm), $F(1,38) = 26.09$, $p < .01$. This is of course the intuitive result, but it conflicts with the predictions of the cognitive contents hypothesis. There were no single- to dual-task decrements in reading speed, and familiarity did not interact with task (single vs. dual), supporting the conclusion that the reading task was being protected by the subjects in the dual-task situation.

Reading speeds were slower in the paragraph than in the phrase presentation, (160 vs. 193 wpm), $F(1,38) = 27.01$, $p < .01$. Subjects reported that the phrase presentation was easier to read than the paragraph presentation in that less work was involved in keeping track of their position in the texts. Furthermore, there was no opportunity for rereading in the phrase condition, which may have resulted in less time overall spent reading. Again, as this effect did not interact with Task, it seems that subjects were able to maintain their performance on reading in the dual-task situation. Finally, there was a practice effect, such that when the single-task condition was presented first, reading speed was 11 wpm slower than for the dual-task (166 vs. 177 wpm), and when the dual-task was presented first, reading speed was 9 wpm slower than for the single-task (178 vs. 187 wpm), $F(1,38) = 11.39$, $p < .01$. With reading as a primary task, it seems important to counterbalance presentation order so that spurious or misleading decrements are not found.

Regression analyses indicated that single task reading speed predicted dual-task speed well, with the semi-partial R^2 of .50, $p <$

.01. None of the other factors were related to single-to-dual task changes, however, indicating that subjects were able to maintain their performance on the reading task.

Reading speed was also analyzed without partialling out single-task performance in order to examine individual differences (see Table 8). As expected, reading speed varied with standardized test score, such that skilled readers read more quickly than less-skilled readers (199 vs. 155 wpm). The only significant interaction was between inference test score and presentation. Subjects with low inference scores read the texts 46 wpm faster in the phrase than in the paragraph presentation, whereas the reading speed of subjects with high inference scores increased by only 21 wpm (see Table 9). Reducing resource demands by segmenting helped subjects with low inference scores to increase their reading speed more than it helped those with high inference scores.

These results are consistent with a proposal made by Dixon, Twilley, & LeFevre (1987). According to Dixon et al. (1987), the inference test distinguishes between reflective and superficial readers. Reflective readers spend a large amount of time processing the content of the text and activating related information. Thus, they do well on the inference questions that require the use of world knowledge in combination with the information presented in the text. However, superficial readers process the text much less thoroughly and do relatively poorly on inference questions, although they may do relatively well on comprehension tests like the Nelson-Denny which also assess microprocesses, that is, speed and surface level processing such as anaphoric reference. In the phrase presentation,

superficial readers benefit from the reduction in microprocessing demands because their performance is heavily influenced by limitations in those skills. Reflective readers benefit less, because their processing is influenced by the macroprocessing requirements of the text, which were not affected by segmenting.

Comprehension

The number of multiple-choice questions answered correctly for each paragraph (five maximum) was analyzed in a 2(order) by 2(task) by 2(familiarity) by 2(presentation format) analysis of variance, with repeated measures on the last three factors. The only significant effect was that more questions about familiar texts were answered correctly than about unfamiliar texts (3.34 vs. 3.08), $F(1,38) = 5.90$, $p < .05$. This effect was equivalent for the single- and dual-task conditions, indicating that subjects were protecting the reading task in the dual-task situation. This result suggests that either the reading and auditory tone tasks do not use the same resources (but see Britton & Price, 1981), or that subjects maintained performance on the reading task at the expense of the probe task. Regression analyses were used to examine the effects of the individual difference factors on single- to dual-task changes, but none accounted for a significant proportion of the variance, and none of the text-by-subject interactions were significant. These results are encouraging, because they suggest that subjects were fairly successful in following the instructions to emphasize comprehension.

Regression analysis was also used to examine individual differences in comprehension performance without focussing on single- to dual-task decrements. As in the analysis of variance, within-

subject factors included familiarity, presentation, and task (single or dual). The results are shown in Table 10. Subjects with higher scores on the inference test answered more questions correctly than subjects with lower scores although the effect was marginally significant (3.36 vs. 3.07, $p = .069$). This result is consistent with the hypothesis that comprehension will be primarily due to macroprocessing skills that are also assessed by the inference test. Somewhat unexpectedly, subjects with large probed word spans comprehended more than those with small probed word spans (3.39 vs. 3.03). The ability to retain verbatim information during ongoing processing (as measured by probed word span) seemed to facilitate comprehension. A possible explanation for this result is that an ability to retain verbatim information allows the retention of extra information that is useful for macroprocessing but that is usually lost from short-term memory after a proposition has undergone microprocessing (e.g., information that would allow inferences to be made about a character's actions; see also Fletcher, 1981, 1986; Goldman, Hogaboam, Bell, & Perfetti, 1980).

Presentation format interacted with reading span, as is shown in Table 11, although the effect was marginally significant. Subjects with small reading spans showed a small decrease in comprehension from the paragraph to the phrase condition, whereas subjects with large reading spans showed a larger increase. This result is opposite to that expected, according to the limited-resource model. Phrase presentation was expected to reduce the processing demands for small span subjects and produce an increase in comprehension (cf. Chen, 1986). Because reading speed increased in the phrase condition,

without any appreciable decline in comprehension, this result could be interpreted as an overall improvement for all subjects. The finding that subjects with large spans showed greater facilitation may indicate ceiling effects were operating in previous studies. For example, in the Chen study, reading speed was controlled, so only improvements in comprehension were possible. Subjects with large spans might have reached the limit of possible improvements in comprehension, whereas subjects with small spans still had room to show an increase. The effects of segmenting text evidently will require further research.

Familiarity, presentation format, and Nelson-Denny score also interacted. As shown in Table 12, the familiarity advantage was largest for subjects with low scores on the Nelson-Denny test in the paragraph condition. In the phrase condition, subjects with low Nelson-Denny scores performed similarily on the familiar and unfamiliar texts. In contrast, subjects with high scores on the Nelson-Denny test showed a familiarity advantage only in the phrase condition. If it is assumed that the Nelson-Denny primarily consists of relatively unfamiliar material, then it seems that the phrase presentation helps to equate performance on unfamiliar texts for skilled and less-skilled subjects. Less-skilled readers had lower comprehension scores than skilled readers on unfamiliar texts but only in the standard (paragraph) presentation. Differences as a function of skill on the <u>familiar</u> texts may reflect individual variability in prior knowledge of certain topics.

The relationship between speed and comprehension was moderate (overall $r=.30$, $p < .10$). The two indices of performance were related

to different individual differences and were differently affected by phrase presentation. The direction of the relationship is inconsistent with a speed-accuracy tradeoff. Thus, it seems reasonable to conclude that they are relatively independent measures of performance (see also Dixon et al., in press; Palmer et al., 1985).

Summary

The results of this study did not support the cognitive contents hypothesis proposed by Britton (see Britton & Tesser, 1982). Some subjects did show the predicted effect (i.e., slower secondary task latencies on familiar versus unfamiliar texts), but an explanation based on the size of the processing units seemed to account for the results. Controlling unit size effectively reduced differences in decrements between texts and between subjects on the probe response times, challenging the assumption that the auditory probe task overlaps with the resource requirements of the reading task. Therefore, Experiment 1 does not appear to test the resource limited view of reading or of individual differences in reading because the secondary task did not seem to index resource availability.

The within-subject contrast between the two presentation formats has some implications for future studies of reading. In the present study, differences in the presentation format of the text varied as a function of scores on the individual difference measures. For example, subjects with low scores on the Nelson-Denny test improved their comprehension on unfamiliar texts in the phrase presentation as compared to the paragraph presentation. Such findings indicate that data collected using presentations that are not exactly equivalent to standard reading experience should be interpreted cautiously. At

least when the focus is on individual differences, it seems important to replicate findings across a variety of reading paradigms and types of text.

EXPERIMENT 2

In Experiment 1, little support was found for the cognitive contents hypothesis proposed by Britton. Further, the probe tone secondary task was not found to be a useful measure of the resources available during reading. When text was presented in phrases, any differences in the probe decrements were attenuated, suggesting that the probe response times were reflective of some aspect of processing that does not necessarily involve resource availability. Therefore, in order to test the resource-limited view of reading, it seemed necessary to design a different secondary task in which the resource requirements clearly overlapped with the resource requirements of reading processes. To address this issue, a different secondary task was used in conjunction with a familiarity manipulation similar to that used in Experiment 1. In addition, an interruption manipulation was included that may also be sensitive to the resource requirements of reading.

In Experiment 2, a dual-task measure was used that involved processes that were similar to the processes used in reading. In the verification task, subjects read texts that were presented in short phrases. Occasionally, after a phrase had been presented, a single word appeared. Subjects had to decide whether that word had been present in the immediately prior phrase. When the word was actually present in the phrase, the time required to verify the word was assumed to index available resources. A slow verification time may also reflect (a) the loss of verbatim information from short-term store, (b) limitations in the amount of working memory available to keep verbatim information activated, and/or (c) a superior chunking

strategy that allows information to be processed and disposed of quickly. In order therefore to focus on decrements in performance (assumed to reflect available resources) subjects also performed a single-task version of the verification task in which the phrases were unrelated to one another. The only difference between the single- and dual-task conditions, therefore, was that reading comprehension was required in the dual- but not in the single-task.

The verification task is similar to the probed word task used by Goldman et al. (1980) in which good readers were more likely to have verbatim information available. In the task used by Goldman et al., subjects were asked to recall the word that followed a probed word when they were interrupted during reading. According to Goldman et al., skilled readers have more working memory available than less-skilled readers. In the present view, skilled readers are assumed to be more efficient and so should have more resources for processing the secondary task than less-skilled readers.

The second manipulation used in Experiment 2 was modelled on an interruption paradigm developed by Glanzer and his colleagues (Glanzer, Dorfman, & Kaplan, 1981; Glanzer, Fischer, & Dorfman, 1984). Occasionally, after reading a sentence, subjects were interrupted and had to read information that was unrelated to the current reading task. Glanzer used both interleaved passages and unrelated statements as interruptions (Glanzer et al., 1984). In the present study, the interruptions were factual statements that were unrelated to the text being read. Subjects were instructed to try and remember the statements for later recognition. The interruption was assumed to disrupt the surface structure of the preceding sentence that was

present in working memory (Glanzer et al., 1981, 1984; Glanzer & Nolan, 1986).

In Glanzer's studies, subjects spent more time reading the sentence after an interruption than they did if they were not interrupted. Presumably, after an interruption, verbatim information is lost and therefore information from a more permanent store must be retrieved in order to process the new information and integrate it into the text representation. Efficient readers should be able to keep the verbatim information activated while processing the interruption, and so should be less affected by the interruption than less-efficient readers. Further, because unfamiliar texts are assumed to require more resources than familiar texts, interruptions should be more disruptive during unfamiliar texts.

All texts were presented as phrases because of the nature of the verification secondary task. Presentation in phrases also made it possible to assess an aspect of macroprocessing that was described by Just and Carpenter (1980; Green, Mitchell, & Hammond, 1979; Mitchell & Green, 1978; Aaronson & Scarborough, 1977). Readers have been found to pause at the end of sentences, presumably to integrate the information in that sentence with the text representation. This increased time at the ends of sentences (called the end-of-sentence effect) therefore reflects macroprocessing operations.

Method

Subjects

The first 24 subjects (7 males and 17 females) who participated in Experiment 1 returned after a delay that ranged from 3 days to 3 weeks and participated in Experiment 2.

Materials

Passages were constructed and piloted as in Experiment 1. The passages in the present study were longer than those in Experiment 1 (mean number of words 525 vs. 217 in Experiment 1), so that interruptions could occur at reasonable intervals. Initially, six pairs of passages were constructed. Each pair of passages had the same number of sentences, the same paragraph structure (i.e., paragraph breaks after the same number of sentences), and similar content. Pilot familiarity ratings were collected and the four pairs that produced the largest differences in ratings were used in the present study (see Appendix 1b). The four pairs differed significantly in mean familiarity rating (5.64 vs. 1.98), $t(6) = 7.5$, $p < .05$. Ratings for each passage are shown in Appendix 2.

The passages were segmented with the same rules as described in Experiment 1. Because the passages used in Experiment 2 were considerably longer than those used in Experiment 1, it was necessary to indicate the location of paragraph breaks. At the location of a new paragraph, the phrase "NEW PARAGRAPH" was included. Subjects were instructed to read this information and then continue reading the passage. Answer booklets were given to each subject that included rating scales for the familiarity judgment and the multiple choice questions (see Appendix 3b), plus detailed instructions about the word verification and interruption tasks.

Verification. For each pair of passages, a set of words was selected to be used in the dual-task verification. The words present in the preceding phrases had to appear in the same sentence of the familiar and unfamiliar text. For the single-task verification, a set

of words matched to the dual-task verification words in length and frequency were selected and a list of unrelated phrases was constructed among which the "present" words appeared. These words and the phrases are shown in Appendix 1b. In the single-task verification, subjects read each phrase and verified the words when they appeared, just as in the dual-task condition.

Interruptions. For each pair of passages, two sets of interruption locations were selected. Target sentences followed an interruption and so the target sentences in one set were not interrupted in the other set. None of the target sentences included word verification trials.

Factual statements. The factual statements used for the interruptions are given in Appendix 6. The set of recognition items given to each subject is also shown in the appendix. Of the 60 statements, 28 in the recognition phase were slightly modified to provide lures. None were related to the topics of the passages. During the experiment, each subject saw a slightly different, randomly ordered set of 56 of the total of 60 factual statements.

Apparatus.

As in Experiment 1, passages were presented by an Apple II microcomputer which also collected verification latencies and reading times. Each phrase was presented in the vertical centre of the screen, flush with the left edge. Subjects used a response panel with three keys arranged horizontally. They pressed the centre button to advance to the next phrase, the right key to respond "present" to a verification word, and the left key to respond "not present".

Procedure

The reading span test was administered first, as described in Experiment 1. Total time for this test was about 15 minutes.

Each subject read a total of six passages. Before starting to read, each subject was given oral instructions about use of the response panel and about the two different types of interruptions (i.e., word verification and factual statements). Then they read each passage, rated it for familiarity, and answered the multiple choice questions. The first practice passage ("Cricket") did not have interruptions or verifications in it. The second practice passage ("Russian Childrearing") was preceded by two pages of instructions that reiterated the oral description of the interruption and verification tasks. Each subject read four experimental passages, two familiar and two unfamiliar. There were six different possible combinations of passages, and a latin square was used to create 4 orders within each group. In addition, half the subjects saw interruption set A, the other half interruption set B. Two of each of the four orders within a group were assigned to an interruption set.

After the reading task was finished, subjects attempted to distinguish facts they had actually seen from close paraphrases of those facts. Finally, subjects did the single-task verification, which was very similar to the dual-task reading, except that the density of verification words was higher. Total time to complete this study was about 1.5 hours.

Results and Discussion

Individual Difference Data

The means and standard deviations for each individual difference

measure are shown in Table 1. The sample of subjects that participated in this study are comparable to both the pretest group and to the Experiment 1 sample. The correlations among the individual difference variables are given in Table 13. Because there were fewer subjects than in Experiment 1, the pattern of significant correlations differs from that of the pretest group. However, the values of the correlations are similar, with the exception of the correlation between digit span and inference test score, which is considerably higher than in the larger sample.

Word Verification Data

Errors. Means and standard deviations for correct trials in the single and dual tasks were calculated for each subject and any latencies greater than three standard deviations were defined as outliers and included in the analysis as errors (3% of all trials). The percentage of errors in each condition was analyzed in a 2 (presence) x 2 (familiarity) x 2 (task) analysis of variance, with repeated measures on all factors. More errors were made when the word was present in the preceding phrase than when it was not present (6.36% misses vs. 3.66% false alarms), $F(1,23) = 8.17$, $p < .01$, and more errors were made in the single- than in the dual-task condition (6.24% vs 3.77%), $F(1,23) = 5.69$, $p < .05$. These effects are qualified by a marginally significant interaction between the two factors, $F(1,23) = 3.52$, $p = .074$. There were more misses on present words in the single- than in the dual-task condition (8.80 vs. 3.92%), $F(1,46) = 8.75$, $p < .05$, whereas the percentage of false alarms did not differ between conditions (3.69% vs. 3.62%), $F(1,46) < 1.00$. In other words, there was a relatively high error rate in the single-task

condition for present words. This result may reflect a speed-accuracy tradeoff in the single-task condition and therefore single-task response times may have been underestimated.

If an error was made in either the single or dual task, the corresponding paired item in the other task was also deleted in order to preserve the matching of length and frequency between word sets. Thus, a total of 9.5% of the paired latencies were either errors or outliers. Regression analyses of the paired single- and dual-task error percentages indicated that none of the individual difference measures predicted dual-task performance after the single task was partialled, and there were no interactions between the individual difference factors and familiarity.

Verification latencies. Mean latencies were calculated (excluding errors and outliers) for each subject as a function of presence, familiarity, and task and analyzed in a 2 x 2 x 2 repeated measures analysis of variance. Words present in the preceding phrase were verified more quickly than words that were not present, (943 vs. 1049 ms), $F(1,23) = 18.92$, $p < .001$, words were verified more quickly in the single- than in the dual-task condition, (778 vs. 1213 ms), $F(1,23) = 265.55$, $p < .01$, and these two factors interacted, $F(1,23) = 4.94$, $p < .05$. The difference between present and not present words was smaller for the single- than for the dual-task (70 vs 140 ms). There was no significant effect of familiarity and no other significant interactions.

The increase in latency from single to dual task indicates that verification in the comprehension task required more cognitive resources than in the unrelated phrase (single-task) condition. The

verification task seems to be sensitive to the demands of constructing a text representation, although not to variations in the familiarity of the text. Regression analyses were used to examine the effects of the individual difference factors and the interactions of those factors with familiarity. The single-task measure was partialled first, so the results discussed reflect predicted dual-task scores with the single-task held constant. Words that were present in the preceding phrase were analyzed separately from those that were not present, as it seemed evident that different processes may characterize performance in the two conditions. If a word was present in the preceding phrase it could be matched to the verbatim representation in short-term store. If a word was not present, then some additional search of long-term memory may have been attempted, and an additional decision component was necessary to stop searching and respond.

The analysis for the words present in the preceding phrase is shown in Table 14. In the between-subject analysis, the single-task performance predicted 50% of the variance in dual-task times. Thus, not only are there large decrements from single-to-dual task, but performance on the single-task is highly related to performance on the dual-task.

Other between-subject factors that were predictive of verification latencies included probed word span ($p=.06$) and the running digit span by reading span interaction. The relationship between performance on the verification task and probed word span was of particular interest because of the considerable similarity between the two tasks. In both cases, a word present in a preceding group of words must be either

recalled or recognized. In a sense, the probed word span is another sort of single-task measure for the dual-task verification because probed word span requires similar processes but it occurs in the absence of any text-level coherence. Subjects who did well on the probed word span test were faster on the verification task, perhaps because the processes required in both are relatively similar.

Further, as shown in Table 15, subjects with large reading spans and large running digit spans showed the smallest decrements on the verification task. Efficient processors evidently had more resources available than less-efficient processors. The largest decrements, however, occurred for subjects with a small span on one measure and a large span on the other. As in Experiment 1, the efficiency measures do not seem to be equivalent, although performance on the verification task does seem to be sensitive to some aspect of resource availability that is partially tapped by the three span measures. To test the hypothesis that this joint contribution would be accounted for by Digit Span (which also is related to all span measures), digit span was used in an analysis. However, it did not predict any significant variance, and did not interact with familiarity. These results are consistent with the view that efficiency as measured by the individual difference variables tends to be specific to the particular processes that are involved in the secondary task.

The interaction of familiarity with probed word span is shown in Table 16. Subjects with small spans generally showed larger decrements, but also showed a substantial difference in decrements between familiar and unfamiliar texts. The difference in latencies

between large and small span subjects was greatest on familiar texts. Subjects with small probed word spans seemed to have fewer resources available on familiar than on unfamiliar texts. However, as the effect was marginally significant, this interpretation should be regarded as tentative.

Inference ability also interacted with familiarity to predict verification latencies. Subjects who did well on the inference test verified words more quickly while reading unfamiliar texts than familiar texts (see Table 17), and the familiarity effect was opposite to that predicted by the resource-limited view. In contrast, subjects with low scores on the inference test showed a smaller difference in verification latencies as a function of familiarity, and in the opposite direction. One interpretation of this result is that subjects with high inference scores used more resources on familiar than on unfamiliar texts.

An alternative explanation for these results is that differences in the ability to retain verbatim information are affecting decrements in verification performance. Subjects with high inference scores are thought to be more reflective readers (Dixon et al., 1987) and may therefore be processing more extensively or thoroughly on more difficult texts. Therefore, for subjects with high inference scores, verbatim information is more likely to be available during reading of unfamiliar texts. In contrast, subjects with low inference scores are not processing familiar and unfamiliar texts differently, and so are not more likely to have verbatim information available on unfamiliar texts.

The most obvious conclusion that can be made from the results of

the analysis of verification times is that the status of the verification task as an index of resource availability will remain uncertain until further research has been completed. The processes involved in verification are complex and it is a fairly intrusive task in the context of reading. Successful use of a dual-task paradigm to study resource availability during reading may have to await more precise specification of the processes involved both in candidate secondary tasks and in the reading task itself.

Analysis of the verification words that were not present in the preceding phrase is shown in Table 18. Consistent with the results for the words that were present, single-task performance significantly predicted dual-task performance, probed word span significantly predicted verification latencies, and the reading span by running digit span interaction was marginally significant, with the effects for both variables in the same direction as in the analysis of the present words. Somewhat paradoxically, however, the significant interactions between familiarity and the individual difference measures were the ones not significant in the analysis of the present words. Reading span, running digit span, and Nelson-Denny comprehension all interacted with familiarity to predict verification times for words not present in the previous phrase. As suggested, verification of words not present in the preceding phrase may tap additional retrieval or memory processes that are unnecessary when the word was actually present, further complicating the assumption that decrements on the verification task index available resources. In support of this interpretation, the size of the decrements (after controlling for single-task latencies) that were predicted by the

additional factors was much smaller for words not present than for the words that were present (e.g., on the average only 67 ms versus 457 for present words). Therefore, detailed explanations of these interactions were not attempted.

Summary. Because familiarity did not predict decrements in performance on the verification task, these results are not consistent with a resource-limited view of reading. Verification was assumed to require the same resources as the microprocessing involved in reading. Analyses of individual differences indicated that latencies on verification trials tended to be shorter for subjects with high scores on the probed word span test, and for subjects with high scores on both the running digit span and reading span tests. It seems plausible to conclude that the verification task is sensitive to resource availability as measured by these tests. However, the complicated interactions between familiarity and various individual differences challenge this conclusion and suggest that specification of resource use during reading may require more sophisticated techniques.

Reading times

Reading times for those sentence with preceding interruptions and the corresponding noninterrupted sentences were analyzed in a Set (set A or set B) x Familiarity (familiar or unfamiliar) x Interruption (not interrupted or interrupted) analysis of variance with repeated measures on the last two factors. As in Experiment 1, familiarity of the topic influenced reading times: Sentences in familiar passages were read somewhat faster than sentences in unfamiliar passages (5922 vs. [illegible]), $F(1,22) = 4.28$, $p = .051$. There was also a main effect

of the interruption manipulation: Sentences occurring after an interruption were read more slowly than those that were not interrupted, (5807 vs. 6367 ms), $F(1,22) = 6.80$, $p < .025$. This 500 ms interruption effect is quite consistent with that found by Glanzer and his colleagues in a variety of studies (reviewed by Glanzer & Nolan, 1986).

Of particular interest was the interaction between familiarity and the interruption manipulation. According to a resource-limited view, interruptions should be more disruptive during unfamiliar texts because more resources are required than for familiar texts. Analysis of the sentence reading times indicated that the interruption effect did not differ for familiar and unfamiliar texts, $F(1,22) < 1$. This finding is consistent with Glanzer's explanation for the interruption effect: He has suggested that the interruption causes verbatim information from approximately two previous sentences to be lost from short-term memory. The extra time spent reading a sentence that follows an interruption is used to reinstate the information from preceding sentences. In this view, the information that is lost from working memory is used primarily for forming microstructural coherence relations such as grammatical or syntactic connections or anaphoric reference. Because of the nature of the familiarity manipulation used in the present study, the cohesion requirements did not vary between familiar and unfamiliar texts. Thus, it seems reasonable to conclude that the interruption manipulation is independent of macrostructural manipulations such as familiarity or narrativity.

Previous research has shown that subjects spend extra time at the ends of sentences (Carpenter & Just, 1981; Graesser & Riha, 1984;

Haberlandt & Graesser, 1985; Just & Carpenter, 1980), and that the end-of-sentence effect may be related to reading skill (Purdon, 1983). It seems reasonable to hypothesize that the extra time spent on the end of a sentence may vary with macrostructural manipulations of the text, as it is assumed that the extra time is used for integrating the information in the sentence with the reader's representation (Carpenter & Just, 1981; Haberlandt & Graesser, 1985). Reading times on the first, last, and intervening phrases were analyzed in a 2(familiarity) x 2(interruption) x 3(position: first, middle, last) repeated measures analysis of variance. The dependent measure was reading time per word, as the phrases varied (across passages) in the number of words present. For each subject, means were calculated across the two passages at each level of familiarity.

The main effects paralleled those of the analysis of sentence reading times. Less time was spent on each word in familiar passages than in unfamiliar passages (301 vs. 321 ms), $F(1,23) = 4.78$, $p < .05$, and reading times were longer after an interruption (334 vs. 289 ms), $F(1,23) = 20.62$, $p < .001$. There was also a main effect of the position of the phrase, $F(2,46) = 94.70$, $p < .001$, such that the reading times decreased from 368 ms for the first phrase to 291 and 274 ms for the middle and last phrases respectively. Both the linear and quadratic trends were significant, Fs > 20, ps < .01. However, these main effects were qualified by two significant interactions. As shown in Table 19, familiar texts were read significantly more quickly than unfamiliar texts only on the last phrase, $F(1,49) = 28.21$, $p < .01$. This result suggests that the effect of topic familiarity is most evident for integration processes occurring at the end of each

sentence.

The interaction between interruption and position was also significant, $F(2,46) = 22.41$, $p < .001$, as shown in Table 20. Tests of simple effects indicated that the interruption effect was only significant for the first phrase, $F(1,49) = 45.54$, $p < .001$. Evidently the disruption in processing caused by the interruption was relatively short lived. Subjects may have paused on the first phrase after the interruption, retrieved the necessary information and proceeded to read normally. This is consistent with the view that the extra time after the interruption is used primarily to reinstate the information required to link together the text at a micro-level. If the interruption interfered more with conceptual processing, then it seems likely that processing at the end of the sentence would also be affected by the interruption.

Regression analyses were used to examine interactions between individual difference variables and the within-subject factors described above. Because of the large number of possible interactions, the interactions of each individual difference variable with the within-subject factors were tested separately. Only the Nelson-Denny test score showed any significant interactions with the within-subject factors. In the analysis shown in Table 21, presentation of the results was simplified by including only those factorial interactions shown to be significant in the analysis of variance. The two degrees of freedom in the position variable were coded as the linear and quadratic components. As expected, the significant factorial interactions parallel the results from the analysis of variance. Subjects read the unfamiliar texts more slowly

than the familiar texts, they read more slowly after an interruption, they spent more time on the final phrase on unfamiliar texts, and they spent more time on the initial phrase after an interruption.

The regression analysis of the between-subject factors indicated that subjects with higher scores on the Nelson-Denny test tended to have shorter reading times. This effect interacted with the interruption by position interaction. As shown in Table 22, subjects with high Nelson-Denny scores were less affected by the interruption than those with low Nelson-Denny scores, and this was primarily reflected in shorter reading times on the first phrase. The interruption effect was twice as large for low-scoring than for high-scoring subjects. This finding is consistent with the hypothesis that skilled readers will be less affected by the interruption, presumably because their processes are more efficient than those of less-skilled readers and they may be more likely to retain verbatim informion across the interruption.

Comprehension

The percentage of comprehension questions answered correctly was analyzed in a one-way repeated measures analysis of variance. More questions were answered correctly about familiar than about unfamiliar texts (64.2 vs. 49.8%), $F(1,23) = 20.02$, $p < .001$. Regression analyses indicated that, of the individual difference measures, only the running digit span score was even marginally related to comprehension. Subjects with larger running digit spans comprehended less than those with smaller running digits spans ($p = .06$). There were no significant interactions of the individual difference scores with familiarity. It was somewhat surprising that the inference test

and the Nelson-Denny comprehension score did not predict comprehension performance. However, the phrase presentation may have been beneficial for the less-skilled subjects and resulted in equivalent performance for the two skill groups, as suggested by the results of Experiment 1 and by previous research (e.g., Chen, 1986; Cromer, 1970).

Fact recognition

The number of facts correctly recognized was significantly correlated only with inference test score (r = .414, p < .05). Subjects who did well on the inference test seemed to have been more careful readers (see Dixon et al., 1987) and they may have been more conscientious about processing the information in the interruption.

Summary

The interruption manipulation used in the present study successfully replicated the results of Glanzer and his colleagues (e.g., Glanzer et al., 1984): Sentences were read more slowly after text was interrupted than when it was not interrupted. In the present study, this finding was extended in two ways. First, it was clear that the interruption effect was primarily confined to processing time on the first phrase after the interruption. Second, the interruption did not interact with familiarity, suggesting that the extra time after an interruption is used primarily for microprocessing operations such as word-level cohesion and between-sentence continuity, characteristics that were held constant in the texts used for the present research.

One difference between the present study and previous research was the finding of a large beginning-of-sentence effect. The phrase

presentation, in combination with the interruption manipulation, had the effect of producing a substantial decline in reading time across phrases in the sentence (see Mitchell & Green, 1978).

In general, the results of this experiment did not support the resource-limited view of reading. Familiarity was not related to decrements in dual-task performance, suggesting that the resource requirements of processing familiarity and of verification did not overlap. The interruption effect, which was also assumed to index resource availability, was also independent of familiarity. Familiarity was, however, related to end-of-sentence processing, which is consistent with the assumption that both reflect macroprocessing operations.

The results of the analyses of individual differences were consistent with the view that resource limitations may affect processing in that the efficiency measures tended to predict dual-task performance. However, reading skill did not interact with performance in straightforward ways. Comprehension was not related to reading skill, possibly because phrase presentation affected processing differently for skilled and less-skilled readers. According to previous findings (Just & Carpenter, 1980; Purdon, 1983), the inference test score had been expected to interact with end-of-sentence processing. The present results suggest that end-of-sentence processing is not a source of individual differences in comprehension (cf., Just & Carpenter, 1980).

GENERAL DISCUSSION

The two experiments described in this paper were designed to test the resource-limited view of reading. Only a limited amount of research has directly addressed the role of resource limitations even though this view is the most widely accepted of current theories of process interactions in reading (e.g., Just & Carpenter, 1987; Perfetti, 1985; Stanovich, 1980). The work done by Britton and his colleagues (e.g., Britton et al., 1978) is the most directly relevant. However, Britton's results are controversial and may not be easily replicable, as in Experiment 1. Certainly, Britton's research is not often cited by current theorists concerned with resource limitations in reading (cf. Carpenter & Just, 1981; Just & Carpenter, 1980, 1987; Perfetti, 1985; Perfetti & Roth, 1981; Stanovich, 1986a, 1986b; Thibadeau, Just, & Carpenter, 1983).

According to the resource-limited view, a single source of cognitive resources exists that is equally available to all reading processes. That is, resources are assumed to be undifferentiated. In the present research, dual-task methodology was used to assess resource availability during reading. Increases in the resource requirements of reading were expected to produce decrements in performance on a secondary task. The greater the resource requirements, the greater the predicted decrement in performance. The resource requirements of reading were varied by manipulating the familiarity of the topics of the texts: Unfamiliar topics were assumed to demand more resources than familiar topics.

The present results were not consistent with an undifferentiated-resource view. Changes in the familiarity of the topic of texts did

not result in differential decrements in secondary task performance. Furthermore, the present results suggest that the dual-task method used by Britton is not appropriate for testing the resource-limited view. Instead, performance on the secondary task seemed to index interruptibility of processing, rather than resource requirements. Research in support of the undifferentiated-resource view comes primarily from studies done with young readers. At early stages of acquisition, reading comprehension is limited by microprocessing skills, but as these skills improve, limitations in macroprocesses become more important (Curtis, 1980). It has been suggested that reading processes become reorganized as a function of development and that some may become automatic and therefore not require resources at all (LaBerge & Samuels, 1974; but see Herdman, 1987; Humphreys, 1985). That is, children's acquisition of reading may indeed be described well by an undifferentiated-resource model (see Perfetti, 1985), but in adults, reading processes may be differently organized (see also Chall, 1979; Spiro & Myers, 1984).

In the following discussion two alternatives to the undifferentiated-resource view are proposed, (a) a differentiated-resource view, in which resource supplies are associated with independent aspects of processing (i.e., micro and macroprocesses), and (b) a structural-interaction view, in which limitations in processing are linked to the availability of cognitive structures. In both cases, the goal is to attempt to account for the complexity of the processes involved in reading.

The differentiated-resource view of reading

The primary assumption underlying the resource-limited view is

that resources are undifferentiated. That is, all processes require resources from a single source. An alternative is a differentiated-resource view in which independent resources are associated with types of reading processes. In accord with this view, micro- and macroprocesses can be conceptualized as independent but interacting systems that utilize separate pools of cognitive resources. One source is assumed to be associated with microprocesses such as word access and propositional encoding, the other source with macroprocesses such as integration and comprehension. Multiple-resource models (Navon & Gopher, 1979) have been proposed by a number of other investigators in diverse domains (Friedman & Polson, 1981; Herdman & Dobbs, in press; Wickens, 1980, 1981).

Vipond (1980) also proposed that micro- and macroprocesses used independent cognitive resources. He found some support for the assumption that micro and macroprocesses are independent: A microprocessing manipulation (lexical difficulty) and a macroprocessing manipulation (scrambled paragraphs) had additive effects on recall performance. However, Vipond did not directly test whether the resource demands of the micro and macroprocesses were also independent.

There is, in fact, little available research that directly addresses the differentiated-resource view. The most relevant evidence is somewhat circumstantial, involving differences that have been observed between two aspects of reading performance, speed and comprehension. To interpret this evidence within a differentiated-resource model, the assumption is made that speed variations are primarily due to variations in the efficiency of microprocesses,

whereas comprehension variations (observed independently of speed) are primarily due to variations in the efficiency of macroprocesses. Speed is primarily linked to the processes involved in translating written symbols into mental units (microprocesses such as word recognition and segmentation). In contrast, comprehension occurs after the microprocesses have submitted output to the macroprocesses. In support of the distinction, the correlation between speed and comprehension tends to be moderate, as was found in Experiment 1 (Palmer et al., 1985; see also Masson, 1985, for discussion). Dixon et al. (in press) showed that relatively pure measures of speed versus comprehension (i.e., reading rate and an unspeeded inference test), were predicted by different factors in a causal model. Palmer et al. (1985) also identified speed and comprehension as separable indices of reading skill. Note, however, that the two indices are not completely independent measures of micro and macroprocessing. Reading times are dominated by microprocesses, whereas comprehension is dominated by macroprocesses. Futhermore, the accuracy of this assumption will depend upon the particular type of reading time or comprehension measures that are used.

Evidence for a dissassociation between speed and comprehension comes from research by Graesser et al. (1980). Regression techniques were used to show that slow and fast readers differed in the amount of time allocated to microstructural components, such as the number of words in a sentence, syntactic processing, and processing propositions. In contrast, differences in the purpose of the reading task (essay questions vs. multiple choice) produced differences in time allocated to macrostructural manipulations such as narrativity,

familiarity, and new concepts. Similarily, Graesser and Riha (1984) found that the amount of time allocated to microprocesses varied with reading speed, whereas time allocated to macroprocesses varied with comprehension skill.

Further support for a distinction between speed and comprehension comes from research done by Jackson (1980; Jackson & McClelland, 1975, 1979). The most important predictor of "reading efficiency" (speed times comprehension) was listening comprehension skill. Name code access (presumably a microprocessing factor) accounted for only 10% of the variance in reading efficiency and most of this was probably related to the speed component of that measure. (The raw speed score in words per minute was multiplied by percent correct on comprehension which had a smaller range. Therefore, speed contributed more heavily to the combined score). When speed and comprehension are evaluated independently with adult readers, it is clear that the two measures are not equivalent indices of performance.

In summary, the notion that speed and comprehension are not interchangeable measures of performance is consistent with the hypothesis that micro and macroprocesses may independently influence performance. Further research is necessary, however, to directly address the issue of whether the independence of processing extends to resource availability.

Results of the Present Research

The results of Experiment 1 are consistent with the differentiated-resource view in that micro and macroprocessing manipulations were affected by different aspects of performance. Presentation format was assumed to reduce the microprocessing required

because the processing units were provided, and so less segmentation and propositional encoding would be necessary. Consistent with the differentiated-resource view, presentation format was related to secondary task performance, which was assumed to require the same resources as microprocesses, and to reading speed, which was also assumed to primarily index word and phrase-level processing. In contrast, familiarity was assumed to primarily affect the operation of macroprocesses, such as those required to construct the text representation in memory. Familiarity was not directly related to secondary task performance. These results support the assumption that macroprocessing resources are independent of microprocessing resources. Familiarity, however, did have an effect on comprehension, presumably through overlap in demand for macroprocesses. Furthermore, familiarity and presentation format did not interact, except as a function of subject characteristics, again supporting the distinction between micro and macroprocessing resources. Familiarity did affect reading speed, however, suggesting that this measure was tapping a mixture of micro and macroprocesses.

In Experiment 2, the interruption effect was assumed to primarily affect the microprocessing operations involved in linking together the text with respect to anaphoric references (Glanzer & Nolan, 1986). Consistent with the differentiated-resource view, the interruption effect was independent of familiarity. Verification was also assumed to require the resources involved in microprocessing and also did not interact with familiarity. Only end-of-sentence processing, which is assumed to index the macroprocesses involved in constructing the text representation (Just & Carpenter, 1980; Mitchell & Green, 1978),

interacted with the familiarity of the texts. Therefore, consistent with the differentiated-resource view, the resource requirements of macro and microprocessing were independent, and manipulations at different levels of processing affected different aspects of performance.

The results of the individual difference analyses, however, do not clearly support either the differentiated- or the undifferentiated-resource view, although they are generally consistent with the notion that resource limitations are a source of individual differences in reading performance. Decrements in secondary task performance tended to vary with the efficiency measures (Experiment 2), whereas reading performance as measured by speed and comprehension varied with the skill measures (Experiment 1). In addition, macroprocessing was not completely independent of microprocessing, as evidenced by the complicated interactions between the individual difference factors and experimental manipulations such as presentation format and familiarity.

A factor that greatly complicates interpretation of the individual difference results is that the measures of efficiency and of skill are multifaceted. The efficiency measures were only moderately intercorrelated, suggesting that they might also have minimal overlap with the efficiency of the processes involved in reading. Even reading span, which is assumed to be a fairly direct measure of the efficiency of reading-specific processes (Baddeley, 1986; Baddeley et al., 1985; Daneman & Carpenter, 1980, 1983; Daneman & Green, 1986) exhibited complicated patterns of interactions with secondary task performance.

Furthermore, the notion of "reading skill" as a single measure has been challenged by recent research (Dixon et al., in press; Palmer et al., 1985). For instance, the standardized test score that was used in the present research as an index of reading skill probably taps into a wide range of reading performance, from relatively simple surface processing skills to more complex inferencing operations. As detailed in the instructor's handbook (Brown et al., 1981), the Nelson-Denny test is highly dependent on speed. Masson (1984) found that Nelson-Denny scores predicted reading comprehension performance only when time was severely restricted (a skimming condition). The importance of speed in determining individual differences in Nelson-Denny performance suggests that this particular measure of skill may index variations in microprocesses that are not directly causing differences in comprehension. More generally, the complexity of processing that is measured by standardized reading tests argues against their being useful for understanding sources of individual differences in reading. As with most standardized achievement tests, it is never easy to pinpoint the source of the differences reflected in the test scores because of the wide range of skills that contribute to performance (see Carroll, 1982). It may be far more enlightening to measure the particular skill of interest and relate that to reading performance.

The inference test, on the other hand, was designed to focus on comprehension, and was consequently expected to be less susceptible to microprocessing variations. However, the explanatory power of this test is also limited because the particular processes and strategies that are involved have not been outlined in detail (Dixon et al., in

press) and the reliability of the test may be low. Therefore, any conclusions about the importance of a particular relationship between a skill measure and some aspect of performance must be tempered by the limitations in our understanding of the skill measure itself. As the interactions among reading processes become better understood, more specific tests of particular skills will be developed. The differentiated-resource view may contribute to this process because it helps to highlight differences between skills (e.g., micro and macroprocesses) that should be predictive of independent aspects of performance.

Segmentation of text

Segmentation of the text into phrases was intended to reduce the processing demands of reading, specifically at the level of microprocessing. According to the undifferentiated-resource view, segmenting should facilitate comprehension by increasing available resources. Previous studies have shown that, for children, segmenting increases comprehension (O'Shea & Sindelar; Weiss, 1983), whereas, for adults, only less-skilled readers were found to benefit from segmentation (Chen, 1986; Cromer, 1970). In contrast, if the differentiated-resource view is correct then segmenting should only facilitate microprocessing. In the present research, segmenting text increased reading speed but had little direct effect on comprehension and was independent of familiarity in Experiment 1. These results are consistent with a differentiated-resource view: Reduction in the processing resources required for microprocessing facilitated other microprocesses but did not affect macroprocessing.

The relation between individual differences and segmentation

was not straightforward. According to Cromer (1970) and Chen (1986), less-skilled readers should presumably benefit more from segmenting because they have inefficient processes. Support for this view was found only for subjects with low inference test scores and only on performance as indexed by reading speed. Subjects with large reading spans (more efficient readers, according to Daneman & Carpenter, 1980, 1983) actually showed larger improvements in comprehension than those with small reading spans, although this effect was only marginally significant. Furthermore, subjects with low scores on the Nelson-Denny test (less-skilled readers) benefitted from segmentation on unfamiliar texts, whereas those with high standardized test scores (skilled readers) benefitted on familiar texts. Because only segmented texts were used in Experiment 2, it was not possible to contrast performance with normal reading. However, there were no overall effects of skill or efficiency on comprehension, suggesting that segmentation of text had the effect of equating performance for all subjects.

In summary, for adults, the effects of segmenting text may be to increase reading speed over unsegmented reading speed and to affect comprehension differentially for skilled and less-skilled readers as a function of text characteristics. Mitchell (1984) discusses the use of segmented presentation (termed subject-paced reading) as a methodology for studying reading processes and recommends its use for studying individual differences because of the control over presentation that is possible. The results of the present research, however, recommend caution when using this method for studying individual differences. Phrase presentation in Experiment 1 had the effect of reducing individual differences in comprehension (for

reading span and for Nelson-Denny score on unfamiliar texts). Creating segments or propositions during reading may be an interesting source of individual differences that is lost when the units of processing are provided. The result of segmentation may be to equate the quality or content of the information in each segment for all subjects, thereby facilitating processing without differentially reducing resource demands for skilled and less-skilled readers.

Implications of the differentiated-resource view

A number of implications of the differentiated-resource view are different from those of a single-pool, resource-limited view. For example, a controversy exists about the best way to characterize dyslexia. According to Perfetti (1985), dyslexia represents the low end of the reading skill continuum defined by the efficiency of microprocessing and so there is nothing unique or different about the reading processes of dyslexic readers. That is, extreme difficulty in reading represents a quantitative deficit. Others (eg. Stanovich, 1986a) claim that dyslexics have a specific deficit related to processing written information such that their reading processes are qualitatively different than those of other readers.

The differentiated-resource view is consistent with a qualitative- or specific-deficit explanation of dyslexia because of the assumption that reading skill among adults varies with the efficiency of macro- rather than microprocesses. In this view, less-skilled adult readers have inefficient macroprocesses. Dyslexics, however, have severe problems with abstract phonological skills that are basic to reading acquisition (Mann, 1986; Stanovich, 1986b). This disability presumably makes it extremely difficult for dyslexics to achieve even

marginally fluent microprocesses. Therefore they may be a qualitatively different group because their microprocesses are very inefficient and may be causing their reading problems. Consistent with this view, disabled readers seem to have adequate macroprocessing skills (as shown by their high IQ scores) and so are limited by their microprocessing ability. In this sense, they constitute a group that is not representative of the continuum of reading skill, when that continuum is defined by macro rather than microprocessing efficiency.

A second, related implication of the differentiated-resource view is that reading-level matched control designs are problematic in the elementary grades. A skilled grade two reader may be performing well relative to other grade two children for different reasons (i.e., efficient microprocesses) than a less skilled grade four reader is performing poorly relative to other grade four children (i.e., inefficient macroprocesses). Therefore, using skilled grade two readers as reading-level matched controls for less-skilled grade four readers may produce confusing or misleading conclusions. Longitudinal studies that chart sources of individual differences are necessary to assess this implication (see Stanovich et al., 1984a).

If the differentiated-resource view correctly describes the organization of reading processes in adults, then it is important to pursue the distinction between speed and comprehension as indices of reading performance, and especially of reading skill. However, reading <u>time</u> can index the operation of both micro and macroprocesses, and so research should be focussed on differences in the allocation of time to particular processes as a function of text or subject characteristics. For instance, a large portion of the variance in

reading times is usually accounted for by microstructural components such as word length or word frequency (e.g., Graesser & Riha, 1984; Haberlandt & Graesser, 1985; Just & Carpenter, 1980). Therefore, the amount of variance that is left to be accounted for by macrostructural factors may be much smaller and may only be detectable with careful design of materials that allow fine-grained analysis. Global measures (i.e., of reading speed) are insufficiently precise and therefore may not be very useful for testing the differentiated-resource view. Careful analyses of reading times have been pioneered by Graesser and his colleagues (e.g., Graesser et al., 1980; Graesser & Riha, 1984; Haberlandt & Graesser, 1986) but need to be extended and carefully applied to analyses of individual differences (e.g., Graesser & Riha, 1984).

Another implication of the differentiated-resource view is that training programs for adult poor readers should focus on macro rather than microprocesses (cf., Frederiksen et al., 1985a, 1985b). The results of various studies support the conclusion that language comprehension skills are an important aspect of reading comprehension (e.g., Bock & Brewer, 1985; Jackson, 1980; Jackson & McClelland, 1975; Mann, 1986; Sticht & James, 1984). However, the focus has typically been on the microprocessing factors that tend to be correlated with reading performance (e.g., Frederiksen, 1982). A more fruitful approach for improving comprehension may be to increase the macroprocessing skills of poor readers (e.g., Palincsar & Brown, 1984).

The differentiated-resource view also has implications for theories of the development of reading skill. In this view, sources

of individual differences in reading skill are different depending on the developmental level: Less-skilled young readers are expected to have inefficient microprocesses whereas less-skilled adult readers are influenced by inefficient macroprocesses. This prediction is consistent with, for example, Chall's (1979) description of reading stages in which different processes determine skilled performance at different levels of development. In contrast, in the undifferentiated-resource view, sources of individual differences in reading skill are relatively homogenous as a function of age: Both older and younger readers are limited by the efficiency of local reading processes (Perfetti, 1982, 1985). In other words, a less-skilled young reader does not comprehend well for the same reason as a less-skilled adult reader.

A Structural-Interaction Approach

Both the undifferentiated- and the differentiated-resource views are based on the assumption that processes compete for attentional resources. An alternative possibility is that processes interfere only to the extent that they compete for specific cognitive structures. That is, the lack of an interaction between familiarity and secondary task performance in the present research may not reflect independence of resource pools, but rather that these two tasks use separate structures. To provide a uniquely structural account of the present results, working memory (and/or short-term memory) structures are assumed to be independent of long-term memory structures. All of the tasks used in the present research can be described as primarily dependent either on working or on long-term memory. In this view, tasks and manipulations that require working memory structures should

be independent of those that require long-term memory structures. In the current research, the efficiency measures of running digit span, reading span, and probed word span were assumed to primarily require working memory, as did the probe response measure, the interruption manipulation, and the verification manipulation. Immediate manipulation and short-term retention of information were required for all of these tasks.

In contrast, familiarity was assumed to require the retrieval of information from long-term memory and the incorporation of this information into the permanent representation of the gist of the text. Probe response time, verification, and interruptions were independent of familiarity, presumably because they made minimal demands on long-term memory.

The structural-interaction approach seems consistent with various results of the two experiments and was used, in fact, to account for some of the more intractable results. The interruptibility explanation for the results of Experiment 1 is essentially a structural explanation, as is the discussion of the interruption effect provided, both by previous researchers (e.g., Glanzer et al., 1984) and in Experiment 2. The presence of information in working memory as part of the reading task is assumed to interfere with the processing of additional information, whether in the form of an auditory tone, a verification decision, or an unrelated factual statement. The assumption is that it is very difficult to use the same structure for more than one processing event. Familiarity, on the other hand, is less demanding of working memory and so does not interfere with processing in these tasks.

As with the differentiated-resource view, the results of the individual difference analyses do not neatly fit the structural-interaction explanations. In Experiment 1, running digit span interacted with familiarity and with presentation format, but in a different pattern than reading span, necessitating a much more complicated explanation of the structural overlap between the various processes. It seems that running digit span and reading span do not use working memory structures in equivalent ways. In effect, assumptions must be made about how the two tasks use working memory. Running digit span may be a measure of the flexibility of processing in working memory (i.e., how quickly information can be updated), whereas reading span may more faithfully index working memory capacity. In this view, subjects with small running digit spans are slower to switch between the probe and reading tasks when the incoming material is familiar because the familiar texts are being read more quickly, taxing the updating capabilities of working memory. In contrast, subjects with large reading spans have large working memory capacities, that quickly become clogged with information from the familiar texts. The surfeit of information in working memory limits the ability of these readers to process the incoming probe. In both cases, the phrase presentation controls the size of the processing units and therefore the load of information in working memory, so that differences between familiar and unfamiliar texts are reduced.

It seems clear that the structural and resource-limited approaches do not preclude one another. In fact, it may be most reasonable to assume that both structural requirements and resource limitations will influence performance (Underwood, 1978). Integration of structural

and resource approaches have been proposed by a number of theorists (e.g, Friedman & Polson, 1981; Herdman & Dobbs, in press; Kahneman, 1973; Wickens, 1980, 1981) on the assumption that independent resource pools may be associated with processing structures. For example, Friedman and Polson (1981), proposed that independent resource supplies are associated with the cerebral hemispheres. It seems likely that our understanding of the processes involved in reading is progressing towards an integrated approach that includes both structural and resource interactions in complex models (e.g., Carr, Brown, & Vavrus, 1985).

In this view, an important first step will be to outline the structures associated with various resource supplies. For example, microprocessing requires a surface structure buffer (such as phonological short-term memory; Baddeley, 1986), a working memory for processed propositions (Baddeley, 1986; Kintsch & van Dijk, 1978), a lexicon for word access, plus a parser for syntactic analysis. Macroprocessing requires a long-term memory, as well as imagery and spatial buffers for constructing a situation model (van Dijk & Kintsch, 1983). The integration of structural and process-oriented approaches to the study of reading has been termed a strategical approach by van Dijk and Kintsch (I983) and the focus on the interactions between processes and structures in a system has been referred to as the skill-theoretic approach by Carr (1985).

Limitations of the present studies and future directions

One limitation of the present research was the lack of a microprocessing manipulation to compare to the macroprocessing manipulation (i.e., familiarity). An improved version of the current

research would include a text manipulation that involved microprocesses, such as syntactic complexity (Britton et al., 1983). Under those conditions, the secondary task which involved microprocesses would be expected to show differential decrements as a function of syntactic complexity. A macroprocessing secondary task, on the other hand, should show decrements differentially as a function of the macrostructural manipulation. Such findings would provide clear support for the differentiated-resource view. Of course, careful selection of the materials and of the secondary tasks would be necessary to avoid the pitfalls of studying resource availability with a dual-task approach.

A second limitation of the present research was the difficulty encountered in the interpretation of the various span measures as indices of the efficiency of an individual's reading processes. In the present research, individual differences in efficiency were related to secondary task performance, but in complicated ways that did not seem to reflect much about the efficiency of reading processes. The efficiency measures themselves were not strongly interrelated and it seemed clear that significant predictors of performance varied substantially with the particular task that was being used (e.g., verification versus probe response). One implication of this inconsistency is that the efficiency measures may not have measured individual differences in resource availability as they relate to reading. Instead, the efficiency of the particular processes involved only in the secondary task could have been producing the relations between decrements and efficiency scores.

An alternative approach to the study of individual differences in

resource availability is to directly measure efficiency (e.g., of a particular microprocess) using a dual-task approach, and then to relate this measure to individual differences in reading performance. In a recent study, Herdman and LeFevre (1988) used this method and found that the efficiency of lexical access was predicted by reading speed but not by comprehension of the texts from Experiment 1. That is, the resource demands of lexical access (a microprocess) were related to micro and not macroprocessing skills, in support of the differentiated-resource view. This approach to the study of individual differences in resource availability has its own limitations, as it is time-consuming to get a reliable measure of resource demands and careful selection of both primary and secondary tasks is necessary. Moreover, a strong model of reading processes is required to guide such research. The ultimate usefulness of the differentiated-resource model will be determined by the extent of our understanding of the processes involved in reading.

It seems appropriate to comment on the regression analyses used in this research. The combination of experimental and regression approaches seems to be a useful addition to the toolbox of statistical approaches available to the individual difference researcher. Using the full range of performance on the individual difference measures will usually provide more power to detect relations than that available when subjects are divided into skill groups (e.g., a median split). Furthermore, combinations of factors can be examined (e.g., two types of skill measures such as the Nelson-Denny and inference tests). This would be very difficult with a median split design. One caution, however, is that a large number of subjects should be tested

in order to ensure that a sufficiently powerful test of the interaction hypotheses is possible, especially when the number of individual difference variables is large. Further, as with all regression approaches, the assumption must be made that the measured skill is linearly related to reading performance. If there is some reason to suspect a nonlinear relationship, then a simple regression approach (or a simple median split design, for that matter) will not be useful.

In conclusion, it may not be meaningful to discuss the efficiency of reading processes or resource availability as a general aspect of reading performance. In particular, the results of the present studies do not support the assumption that the resources required by processes at lower levels can be reallocated to processes at higher levels, even though it is clear that macroprocesses require the products of the microprocesses in order to provide the basic grist for comprehension. An alternative approach that may be more useful is to focus on the efficiency of particular reading processes or the joint resource demands of groups of processes, in order to develop models that describe the contribution of these processes to overall reading performance. In this view, categorization of processes into micro and macro may be helpful in pinpointing the sources of individual differences in efficiency that contribute to reading performance. Furthermore, specification of the structural interactions among tasks may also be necessary in order to provide a relatively complete picture of the complexity of reading.

Tables

Table 1

Mean Scores on Individual Difference Measures: Comparison Between Pretest Group, Experiment 1 Sample, and Experiment 2 Sample

		Pretest (n=95)	Exp. 1 (n=40)	Exp. 2 (n=24)
Pretest Variables				
Reading Span (5)	mean	35.7	34.8	35.2
	s.d.	4.8	5.3	4.9
	range	20-42	20-41	25-41
Probed Word Span	mean	12.6	12.4	12.4
	s.d.	3.3	3.6	3.7
	range	2-18	2-18	2-17
Digit Span	mean	70.3	69.6	70.7
	s.d.	10.0	11.0	12.4
	range	42-90	42-90	42-90
Vocabulary	mean	74.3	75.8	73.6
	s.d.	14.4	14.3	15.1
	range	42-99	46-98	46-98
Nelson-Denny	mean	29.3	29.0	28.5
	s.d.	3.5	3.5	3.9
	range	20-36	20-36	20-36
Inference	mean	11.0	10.8	10.4
	s.d.	5.2	5.0	4.5
	range	0-23	3-20	3-19
New Measures				
Running Digit Span	mean		66.0	66.1
	s.d.		6.9	7.7
	range		51-79	51-79
Reading Span (5)	mean		35.9	35.8
	s.d.		5.4	4.6
	range		18-42	23-42
Reading Span (6)	mean		48.1	47.7
	s.d.		8.0	7.4
	range		29-58	29-58

Table 2

Correlations among Individual Difference Measures for Pretest Group (n=95) and Experiment 1 Sample (n=40)

Pretest Group

	Reading Span	Probed Word	Digit Span	Vocab.	Nelson-Denny
Probed Word	.34*	-	-	-	-
Digit Span	.45*	.52*	-	-	-
Vocabulary	.34*	.04	.01	-	-
Nelson-Denny	.39*	.11	.07	.54*	-
Inference Test	.28*	.10	-.03	.32*	.16

* correlations greater than .263 are significant, $p < .01$

Experiment 1 Sample

	Reading Span	Probed Word	Digit Span	Vocab.	Nelson-Denny	Inf.
Probed Word	.36*	-	-	-	-	-
Digit Span	.41*	.58*	-	-	-	-
Vocabulary	.34*	.06	.02	-	-	-
Nelson-Denny	.33*	.06	-.06	.60*	-	-
Inference Test	.38*	.14	.16	.43*	.13	-
New Measures						
Running Digit Span	.30	.35*	.43*	-.28	-.08	.02
Reading Span (5)	.59*	.36*	.33*	.31	.14	.43*
Reading Span (6)	.60*	.45*	.38*	.28	.17	.34*

New Measures - Intercorrelations

	Running Digit Span	Reading Span (5)
Reading Span (5)	.27	-
Reading Span (6)	.22	.92*

* correlations greater than .31 are significant, $p < .05$
correlations greater than .40 are significant, $p < .01$

Table 3

Hierarchical Multiple Regression Analysis of
Reading Span Measures (n=40)

	Original Reading Span	New Reading Span (5)	New Reading Span (6)
Variable			
Digit Span	.167 *	.109 *	.148 *
Running Digit	.019	.020	.004
Probed Word	.016	.035	.076 m
Vocabulary	.150 *	.123 *	.079 m
Total R^2	.352 *	.287 *	.307 *

* $p < .05$

m $p < .10$

Table 4

Regression analysis for Probe Response Latencies in Experiment 1

	hierarch. R^2	semi-partial R^2	coeff.	t(33)	
Between-subjects					
Single task	.379	.258	.558	3.850	*
Running Digit Span	.002	.007	-.942	-.633	
Probed Word Span	.003	.004	1.505	.494	
Reading Span	.003	.000	-.063	-.045	
Nelson-Denny	.037	.037	-3.891	-1.458	
Inference test	.001	.001	-.297	-0.152	
R^2	.425	F(6,33) = 4.062 *			
Within-Subjects				t(99)	
Familiarity	.003	.004	-5.538	-.864	
Presentation	.350	.361	53.313	8.317	*
Familiarity x Presentation	.003	.003	9.675	.755	
R^2	.356	F(3,99) = 22.89 *			
Familiarity x					
Running Digit Span	.000	.000	.115	.070	
Probed Word Span	.003	.005	1.995	.941	
Reading Span	.003	.002	-.662	-.676	
Nelson-Denny	.006	.009	-2.544	-1.328	
Inference test	.003	.000	.369	.265	
Presentation x					
Running Digit Span	.003	.014	1.695	1.662	
Probed Word Span	.010	.002	-1.292	-.608	
Reading Span	.013	.015	-1.643	-1.676	
Nelson-Denny	.022	.022	3.901	2.036	*
Inference test	.000	.002	-.849	-.610	
Familiarity x Presentation x					
Running Digit Span	.035	.025	-4.464	-2.190	*
Probed Word Span	.003	.015	-7.136	-1.683	
Reading Span	.026	.021	3.902	1.991	*
Nelson-Denny	.000	.000	.842	.220	
Inference	.000	.000	1.144	.411	
R^2	.127	F(18,99) = 1.375			

* $p < .05$

Table 5

Decrements in Probe Response times as a Function of Nelson-Denny and Presentation in Experiment 1

	Presentation	
	Paragraph	Phrase
Nelson-Denny		
Low	201	241
High	177	244

Table 6

Decrements in Probe Response times as a Function of Presentation, Familiarity and Running Digit Span in Experiment 1

	Presentation	
	Paragraph	Phrase
Small Running Digit Span		
Familiar	215	236
Unfamiliar	188	250
Large Running Digit Span		
Familiar	174	250
Unfamiliar	180	234

Table 7

Decrements in Probe Response times as a Function of Presentation, Familiarity and Reading Span in Experiment 1

	Presentation	
	Paragraph	Phrase
Small Reading Span		
Familiar	165	243
Unfamiliar	176	232
Large Reading Span		
Familiar	224	243
Unfamiliar	192	253

Table 8

Regression analysis for Reading Speed in Experiment 1

	hierarch. R^2	semi-partial R^2	coeff.	t(34)
Between-subjects				
Running Digit Span	.016	.013	.948	.759
Probed Word Span	.009	.000	.309	.133
Reading Span	.023	.012	.790	.736
Nelson-Denny	.190	.196	6.276	2.989 *
Inference test	.014	.014	-1.234	-.809
R^2	.252	F(5,34) = 2.291 m		
Within-Subjects				**t(245)**
Task	.000	.000	.974	.268
Familiarity	.060	.065	-17.640	-4.856 *
Presentation	.211	.227	32.947	9.071 *
Familiarity x Presentation	.000	.001	-5.290	-.729
R^2	.271	F(7,245) = 13.97 *		
Familiarity x				
Running Digit Span	.003	.000	.065	-.111
Probed Word Span	.003	.003	-1.206	-1.002
Reading Span	.003	.000	-.296	-.532
Nelson-Denny	.000	.002	-.892	-.822
Inference test	.000	.000	.269	.349
Presentation x				
Running Digit Span	.011	.008	.994	1.720
Probed Word Span	.000	.002	1.065	.887
Reading Span	.008	.001	-.399	-.717
Nelson-Denny	.003	.006	1.571	1.446
Inference test	.036	.037	-2.867	-3.636 *
Familiarity x Presentation x				
Running Digit Span	.000	.000	.495	.429
Probed Word Span	.000	.001	-1.414	-.588
Reading Span	.000	.000	-.270	-.243
Nelson-Denny	.003	.001	-1.337	-.616
Inference test	.000	.000	.579	.368
R^2	.070	F(28,245) = 2.541 *		

* $p < .05$
m $p < .10$

Table 9

Reading Speed (in words per minute) as a Function of Inference Score and Presentation Format in Experiment 1

	Presentation	
	Paragraph	Phrase
Inference		
Low	159	207
High	161	180

Table 10

Regression analysis for Comprehension Scores in Experiment 1

	hierarch. R^2	semi-partial R^2	coeff.	t(34)
Between-subjects				
Running Digit Span	.000	.009	-.007	-.644
Probed Word Span	.146	.109	.051	2.229 *
Reading Span	.002	.006	-.005	-.519
Nelson-Denny	.020	.015	.017	.825
Inference test	.084	.083	.029	1.944 m
R^2	.252	F(5,34) = 2.285 m		
Within-Subjects				**t(245)**
Task	.004	.004	-.125	-1.069
Familiarity	.018	.018	-.263	-2.246 *
Presentation	.002	.003	.100	.856
Familiarity x Presentation	.000	.000	.025	.107
R^2	.024	F(7,245) = .951 ns		
Familiarity x				
Running Digit Span	.000	.002	.012	.670
Probed Word Span	.002	.007	-.056	-1.425
Reading Span	.011	.006	.022	1.254
Nelson-Denny	.004	.003	.032	.919
Inference test	.004	.003	.024	.943
Presentation x				
Running Digit Span	.000	.006	-.025	-1.338
Probed Word Span	.018	.006	.049	1.260
Reading Span	.015	.014	.034	1.928 m
Nelson-Denny	.000	.000	.003	.078
Inference test	.000	.000	-.000	-.008
Familiarity x Presentation x				
Running Digit Span	.002	.001	.017	.457
Probed Word Span	.002	.005	.090	1.148
Reading Span	.005	.004	-.038	-1.056
Nelson-Denny	.012	.014	-.139	-1.988 *
Inference	.002	.002	.044	.846
R^2	.077	F(28,245) = .761 ns		

* $p < .05$
m $p < .10$

Table 11

Comprehension as a Function of Reading Span and Presentation in Experiment 1

	Presentation	
	Paragraph	Phrase
Reading Span		
Small	3.34	3.17
Large	2.99	3.36

Table 12

Comprehension as a Function of Presentation, Familiarity, and Nelson-Denny in Experiment 1

	Presentation	
	Paragraph	Phrase
Low Nelson-Denny		
Familiar	3.42	3.26
Unfamiliar	2.79	3.14
High Nelson-Denny		
Familiar	3.18	3.52
Unfamiliar	3.26	3.14

Table 13

Correlations among Individual Difference Measures for Pretest Group (n=95) and Experiment 2 Sample (n=24)

Pretest Group

	Reading Span	Probed Word	Digit Span	Vocab.	Nelson-Denny
Probed Word Span	.34*	-	-	-	-
Digit Span	.45*	.52*	-	-	-
Vocabulary	.32*	.04	.01	-	-
Nelson-Denny	.39*	.11	.07	.54*	-
Inference Test	.28*	.10	-.03	.32*	.16

(* correlations > .263 are significant, $p < .01$)

Experiment 2 Sample

	Reading Span	Probed Word	Digit Span	Vocab.	Nelson-Denny	Inf.
Probed Word Span	.19	-	-	-	-	-
Digit Span	.51*	.52*	-	-	-	-
Vocabulary	.32	-.10	.02	-	-	-
Nelson-Denny	.24	-.10	-.08	.52*	-	-
Inference Test	.42*	.23	.48*	.53*	-.03	-
New Measures						
Running Digit Span	.25	.31	.46*	-.40	-.19	.04
Reading Span (5)	.46*	.39	.58*	.39	.14	.54*
Reading Span (6)	.60*	.49*	.57*	.33	.24	.44*

New Measures - Intercorrelations

	Running Digit Span	Reading Span (5)
Reading Span (5)	.33	-
Reading Span (6)	.28	.89*

(* correlations > .42 are significant, $p < .05$)

Table 14

Regression analysis of verification latencies for words present in the preceding phrase

	hierarch. R^2	semi-partial R^2	coeff.	t(16)
Between-subjects				
Single task	.600	.501	.950	6.24 *
Running digit span	.018	.016	-3.220	-1.11
Reading span	.012	.001	-1.121	-.34
Probed word span	.014	.052	-12.495	-2.02 m
Nelson-Denny	.000	.001	1.408	.28
Inference test	.007	.000	-.861	-.18
Running digit span x Reading span	.143	.143	-1.377	-3.33 *
R^2	.794	F(7,16) = 8.799 *		
Within-subjects				t(16)
Familiarity	.050	.073	-43.256	-1.557
		F(1,16) = 1.649		
Familiarity x				
Running Digit Span	.010	.015	2.864	.709
Reading Span	.137	.038	-6.603	-1.131
Probed Word Span	.094	.114	17.670	1.950 m
Nelson-Denny	.000	.002	- 1.940	-.256
Inference test	.203	.150	-15.790	-2.231 *
Familiarity x Running Digit Span x Reading Span	.025	.025	.561	.906
R^2	.435	F(6,16) = 2.612 m		

* p <.05
m p < .10

Table 15

Decrements in verification latencies for the running digit span by reading span interaction

	Reading Span	
	Small	Large
Running Digit Span		
Small	412	552
Large	519	346

Table 16

Decrements in verification latencies for the interaction between familiarity and probed word span

	Probed Word Span	
	Small	Large
Familiarity		
Familiar	558	400
Unfamiliar	449	422

Table 17

Decrements in verification latencies for the interaction between familiarity and inference test score

	Inference Test	
	Low	High
Familiarity		
Familiar	448	511
Unfamiliar	475	396

Table 18

Regression analysis of verification latencies for words NOT present in the preceding phrase

	hierarch. R^2	semi-partial R^2	coeff.	t(16)
Between-subjects				
Single task	.570	.408	1.534	4.88 *
Running digit span	.013	.009	-4.303	-.74
Reading span	.004	.000	-0.668	-.10
Probed word span	.044	.081	-26.717	-2.18 *
Nelson-Denny	.001	.000	-.449	-.04
Inference test	.020	.002	3.715	-.35
Running digit span x Reading span	.074	.074	-1.725	-2.08 m
R^2	.726	F(7,16) = 6.046 *		
Within-subjects				
Familiarity	.021	.016	22.547	.698
		F(1,16) = .653		
Familiarity x				
Running Digit Span	.093	.275	13.913	2.930 *
Reading Span	.208	.271	-17.141	-2.912 *
Probed Word Span	.010	.000	0.681	.076
Nelson-Denny	.125	.150	19.450	2.162 *
Inference test	.031	.033	8.320	1.011
Familiarity x Running Digit Span x Reading Span	.000	.001	.142	.192
R^2	.467	F(6,16) = 2.541 m		

* $p < .05$
m $p < .10$

Table 19

Mean reading times (ms per word) in Experiment 2
for the interaction between familiarity and position

	Position of Phrase in Sentence		
	First	Middle	Last
Familiar	382	287	235
Unfamiliar	354	296	313

Table 20

Mean reading times (ms per word) in Experiment 2 for the interaction of interruption and position

	Position of Phrase in Sentence		
	First	Middle	Last
NOT interrupted	309	287	269
Interrupted	427	295	279

Table 21

Regression analysis of phrase reading times in Experiment 2

	hierarch. R^2	semi-partial R^2	coeff.	t(16)
Between-subjects				
Running Digit Span	.001	.000	-.157	-.065
Reading span	.051	.002	-.664	-.210
Probed Word Span	.000	.004	-1.542	-.281
Nelson-Denny	.147	.144	-8.710	-1.800 m
Inference	.000	.000	-.321	-.076
R^2	.199	F(5,18) = .897		
Within-subjects				t(231)
Familiarity	.013	.017	19.708	2.686 *
Interruption	.073	.090	45.056	6.141 *
Linear trend	.211	.263	47.130	10.489 *
Quadratic trend	.030	.036	10.016	3.861 *
R^2	.327	F(11,231) = 12.48 *		
Linear trend x				
Familiarity	.067	.083	-52.865	-5.883 *
Interruption	.071	.088	54.490	6.063 *
Quadratic trend x				
Familiarity	.002	.002	5.323	1.026
Interruption	.024	.031	18.663	3.597 *
Nelson-Denny x				
Familiarity	.006	.006	-3.163	-1.636
Interruption	.013	.007	-4.961	-1.702
Linear	.004	.006	-1.827	-1.544
Quadratic	.000	.001	-.346	-.535
Nelson-Denny x Interruption x				
Linear	.002	.002	-2.400	1.013
Quadratic	.011	.012	-3.091	2.262 *
R^2	.200	F(44,231) = 1.527 *		

* $p < .05$
m $p < .10$

Table 22

Predicted reading times (ms per word) in Experiment 2 for the interaction of Nelson-Denny skill, interruptions, and position

	Position of Phrase in Sentence		
	First	Middle	Last
Low Nelson-Denny			
NOT interrupted	331	321	286
Interrupted	490	324	318
High Nelson-Denny			
NOT interrupted	287	253	252
Interrupted	364	266	239

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Appendix 1a

Passages Used in Experiment 1

Notes: (a) / indicates the location of phrase breaks

(b) * indicates the location of an auditory tone in the phrase presentation

(c) familiar texts have odd numbers: unfamiliar texts have even numbers. Familiar/unfamiliar pairs are contiguous.

(d) numbers of passages are not sequential because replacements made during the familiarity norming were given new, unique numbers.

Passage 101: Edmonton

What does the future hold/ for Edmonton, Alberta?/ It has a brief history/ as a city,/ at least as compared to/ cities in Eastern Canada. Founded by/ the Hudson's Bay Company*/ in 1795,/ Fort Edmonton was/ a bustling trading post/ and was known as/ the 'Gateway to the North'./ However,/ permanent settlement did not commence/ until 1870/ and proceeded sluggishly,/ the situation exacerbated by/ the routing of the CPR rail line/ through Calgary. As recently as/ the Second World War,*/ Edmonton was still/ considered to be/ a small city,/ ranking only/ ninth largest in Canada./ Today,*/ culture, government, and industry/ all contribute to/ its thriving milieu/ and make Edmonton/ a vital and convivial place/ to inhabit./ With a reasonably diverse/ industrial base,/ Edmonton was not/ as devastated by/ the recent economic crisis/ as were some other prairie cities./ The population seems/ to have stabilized,/ and even the climate/ has become less onerous/ or so it seems./ In recent years,/ Edmonton has become*/ the shopping mecca/ of Western Canada,/ if not of North America,/ with the erection/ of gigantic West Edmonton Mall./ The gargantuan mall,/ complete with almost all attractions/ known to man,/ may be contributing to/ Edmonton's relative affluence./ The cavalcades of recreational vehicles/ heading towards the mall each weekend/ may be heralding*/ a promising future./

Passage 102: Louisbourg

What does the future hold/ for Louisbourg, Nova Scotia?/ It has an extensive history,/ one of the most spectacular/ of any town/ in North America./ Founded by/ the French King Louis XIV*/ in 1723,/ Louisbourg was/ a strategic port and base/ for the defense/ of France's American empire./ During its/ first half-century,/ it was fortified,/ twice besieged,/ twice captured,/ and ultimately razed/ by British military engineers./ As recently as/ the turn of the century,*/ Louisbourg was thriving,/ shipping trainloads/ of coal and steel daily,/ all winter long,/ through its ice-free harbour./ Today,*/ raw materials and industrial products/ are moved through/ the larger centers/ to the southwest,/ via deep water ports/ that are necessary/ to accomodate/ modern sea-going vessels./ The once mighty trains/ and loading booms are gone,/ rusting in forgotten yards/ or melted down/ to be added/ to the iron stream/ they once handled./ Little remains but/ a pointless concrete overpass/ and a dilapidated wharf./ In recent years,/ Louisbourg has become*/ a depressed and depressing place,/ a dreary, foggy collection/ of wind-whipped wooden houses/ and reeking fish plants./ Louisbourg,/ like so many other/ of Canada's small towns and villages,/ has been withering and dying/ for the better part/ of a century./ Populated by the ghosts/ of antiquated giants,/ it is shunned/ by a relentless,*/ uncaring future./

Passage 103: Typing

Early typists worked/ with loud manual machines. Because fingers could move faster/ than early typewriters could respond,*/ letters that often occurred sequentially/ were placed far apart. Even so,/ the machinery of the keys/ tended to become entangled,/ and the typewriter would seize. The first typewriters/ were used primarily*/ in large offices. Dispatching typewritten letters/ was a sign of modern practices/ and progressive thinking. Gradually,/ typewritten material became standard/ throughout the business world. Even private persons,/ such as book authors,/ began to produce manuscripts on the typewriter. University professors,/ and even high school teachers,/ began to demand*/ typewritten papers. As typewritten copy/ became more universal,/ the need for legible handwriting declined. With that decline,/ the subject of penmanship/ was de-emphasized by schools. Electric typewriters/ were a major advance*/ over the manual type. Less likely to get jammed,/ they allowed increased speed/ and were also marginally quieter. The most recent advance/ in the field of typing/ has been the advent of the word processor.*/ The availability of cheap, reliable computers/ has revolutionized/ the production of/ all types of printed copy,/ from manuscripts,/ to term papers, to the daily newspaper. Because changes in the material/ are simple to make and to store,/ the word processor/ may have also/ had an influence on composition,/ thereby influencing content or quality.*/ In any event,/ the simple manual typewriter/ may soon be found only/ in museums dedicated to/ archaic machines.

Passage 124: Praktur

Frequently,/ handwriting or lettering has developed/ beyond the utilitarian level. The artistic calligraphy/ that flourished after the 17th century*/ among the peoples/ of Germany, Alsace, and Switzerland/ is known as fraktur./ The term fraktur (fracture)/ suggests lettering/ with breaks or fractures/ in the script. These breaks/ give the lettering*/ an ornamental or decorative effect. Mennonites migrating/ from Pennsylvania to Ontario/ around 1800/ brought this art form/ to Canada./ It flourished in/ certain counties/ with large Mennonite settlements,/ such as Upper York and Waterloo./ Beautifully decorated fraktur songbooks/ were made by Mennonite teachers/ at Vineland/ in the early 1800s./ Drawings and other exercises/ were also commonly produced/ by the practioners*/ of fraktur. The largest output occurred/ in the Mennonite community/ of Waterloo county/ in the 1890s. Several artists/ in the community/ produced exquisite fraktur drawings/ and texts. Anna Weber is/ one of the few women*/ known to have/ practiced the art. She appears to have been/ a lonely individual/ suffering from poor health. Her drawings/ of birds, trees, and animals/ delighted children/ with their whimsical expression.*/ Practice of fraktur/ declined rapidly/ during the twentieth century, along with the general neglect/ of folk art forms,/ cultural knowledge/ and traditions. The art of fraktur/ has been revived somewhat/ in recent years/ with its reintroduction/ into some Old Order (traditional)/ Mennonite

schools/ in southern Ontario communities.*/ During its high point/ in 19th century Ontario,/ fraktur was one/ of Canada's most exuberant/ folk art traditions.

Passage 105: Canada

Canada remains/ a lightly populated country,/ a beautiful land*/ variously desolate and lush. Created by/ the actions of natural upheavals/ in tectonic plates,/ then modified by glacial erosion/ during the last ice age,/ at present,/ the geological strata/ of Canada/ is relatively stable. There are not active volcanos/ in Canada,/ although glaciers still exist/ in the highest mountains/ of the Rockies. The country's scenery is immensely varied,*/ from forested coasts/ and soaring mountains/ in the west,/ to flat limitless prairie/ in the centre of the country,/ to the glacier-sculpted rocky terrain/ of the Shield region. Many fine harbours exist,/ and Canada has more coastline than/ any other country/ except the U.S.S.R. In many parts of Canada,/ the relatively harsh climate required/ settlers of hardy stock./ Even now,/ climatic conditions dictate/ the activities of/ most of the denizens,/ especially in the cold winter months.*/ Much of the country/ is covered by forests./ SNow is common,/ and the northern latitude means/ that darkness prevails/ in the winter. Canada is a land/ rich in varieties of birds and animals/ that are extinct*/ in more populated regions,/ contributing to a vast natural heritage./ There are also/ numerous lakes and rivers/ in the country,/ so that electrical power/ is cheap and widely available. THe rivers,/ many consisting of/ the meltwater from numerous mountain ranges,/ are navigable/ in all but/ the coldest months of the year*./ In short,/ Canada is a country/ that has been changed little*/ by the actions/ of its settlers,/ where nature is the dominant force.

Passage 122: Bhutan

Bhutan lies/ along the lofty ridges/ of the eastern Himalayas,/ a beautiful land*/ variously desolate and lush. The northern part of Bhutan/ is crowded with snowcapped peaks/ that attain heights/ of more than 24,000 feet,/ with high valleys/ that run down/ from the great northern glaciers. The Alpine pastures/ on the high ranges/ are used for grazing yaks/ in the summer months. The country's scenery is immensely varied,*/ from high mountains/ in the north/ to lush semi-tropical rainforest/ in the south,/ with some temperate regions/ in the centre/ of the country. The central region of BHutan/ consists of mountain ranges/ forming north-south ridges. The ridges define/ the course of the country's major rivers/ and separate climatic regions. Differences in elevation/ and the degree of exposure/ to moist south-west monsoons/ encourage a variety of vegetation.*/ This ranges from dense forest/ on the windward slopes/ to Alpine scarcity/ at the higher elevations. The southern part of Bhutan/ is a narrow strip of land/ eight to ten miles wide/ that is covered with/ dense semi-tropical forest. Known as the Duars plain,/ this region is subject ot/ excessive rainfall*/ and so is steamy, hot,/ and unhealthy for human habitation. The people of Bhutan/ are primarily of either Tibetan or Nepalese extraction/ and different ethnic groups/ have

retained their customs. Unfortunately,/ discrimination against the minority Nepalese/ constitutes a major internal political problem/ for Bhutan.*/ In addition,/ Bhutan's isolation and Backwardness/ help to maintain/ its limited agrarian economy/ that is still mired/ in the primitive past.

Passage 107: Wayne Gretzky

Wayne Gretzky may be/ the best and most famous hockey player/ of all time. Born in Brantford, Ontario in 1961,/ at age 17/ he was the youngest member*/ of a major league sports team. The brilliance of his play/ indicates that his abilities/ far surpass those/ of any other hockey player,/ past or present. For instance,/ at the termination*/ of the 1983-84 season,/ he had captured/ 34 individual records. However,/ Gretzky's support/ of the Edmonton Oilers/ indicates that he is not/ an egocentric individualist. The Edmonton Oilers probably owe/ some large proportion/ of their success/ to his guidance. In fact,/ Gretzky's exploits have put/ Edmonton, Alberta on the map/ and even people/ who are not hockey aficionados/ have heard of Gretzky. Such pervasive fame/ seems to be justified. From the time he was/ a mere stripling,/ playing every night*/ on a backyard rink,/ Gretzky's talents placed him/ far above his peers. In return for the adulation/ of his fans,/ Gretzky,/ in stark contrast/ to other major public figures,/ takes his role/ as a hockey hero/ seriously. He supports/ numerous charities/ and lives an exemplary*/ and unblemished life. He seems to be/ acutely aware/ of his responsibilities/ to youthful supporters/ and takes care to demonstrate/ non-controversial and helpful behavior/ when dealing with the press. At times,/ such an attitude has resulted in/ his being accused/ of having a bland and colourless personality,/ especially by unscrupulous American pulp magazines. However,/ his reputation as/ the greatest hockey player/ of all time/ will probably outlast*/ such trivial criticisms.

Passage 108: Wan Po Li

Wan Po Li may be/ the best and most famous Go player/ of all time. Born in Beijing, China in 1961,/ at age 17/ he was the youngest member*/ of the prestigious/ all-China competitive circuit. The brilliance of his play/ indicates that his abilities/ far surpass/ those of any other Go player,/ past or present. For instance,/ at the termination*/ of the 1983-84 championship,/ he had triumphed over/ all the other competitors,/ with the exception of the Grand Master himself,/ Fing Won So. However,/ Po Li's support/ of the Chinese National team/ indicates that he is not/ an egocentric individualist. He journeys with the team/ to adjacent Asian countries/ to challenge those teams/ in grueling week-long sessions. In fact,/ Po Li's exploits have/ raised the status/ of the Chinese Go team/ in the eyes/ of foreign competitors. Such pervasive fame/ seems to be justified. From the time he was/ a mere stripling,/ playing every night*/ with wooden pieces/ handcarved by his peasant father,/ Po Li's talents placed him/ far above his peers. In return for the respect and worship/ of his supporters,/ Po Li takes his role/ as a Go prodigy/ seriously. He supports/ numerous charities/ and lives an exemplary*/ and unblemished life. He is more

than willing/ to coach young Go fanatics,/ and spends hours each week/ answering queries/ about especially complicated situations and moves. At times,/ such an attitude has resulted in/ his being said to have/ an excessively narrow and restrictive perspective,/ especially by rival players. However,/ his reputation as/ the greatest Go player/ of all time/ will probably outlast*/ such trivial criticisms.

Passage 123: Leonardo Da Vinci

Leonardo da Vinci,/ a well-known Italian artist,*/ was renowned for/ the range of his genius/ as a painter,/ sculptor,/ architect, and engineer./ Born near Florence in 1452,/ he was apprenticed at age 15/ to the sculptor/ Andrea del Verrocehio./ Da Vinci went to Milan in 1482/ under the patronage of/ the Duke of Milan/ and in the intervening 18 years/ established his formidable reputation./ On his return to Florence in 1499,*/ he was honoured as/ a famous native son./ His most famous paintings include/ the Mona Lisa*/ and the Last Supper,/ perhaps the most favorite works/ by any Renaissance artist./ Da Vinci painted/ relatively few works,/ and he is perhaps more renowned/ for his notebooks/ on a variety of/ scientific and artistic topics.*/ The notebooks constitute/ several thousand closely written pages,/ illustrated with intricate sketches./ The notebooks are/ in mirror-writing,/ that is, backwards./ In spite of this idiosyncrasy,/ the notebooks contain/ much that indicates/ Da Vinci was/ far ahead of his time./ He had a unique view/ of the goals and purpose/ of scientific inquiry/ into the workings/ of the human body/ and natural and physical laws,/ as well as/ an amazing mechanical inventiveness./ This genius was in spite of/ his rudimentary education/ in the basics*/ of reading, writing, and arithmetic./ Da Vinci spent/ his last working years in France,/ and died in 1519./

Passage 110: Wyatt Eaton

Wyatt Eaton,/ a well-known Canadian portrait painter,*/ was the founder/ of a number of/ national and international art societies./ Born at Philipsburg, Quebec in 1849,/ he studied for a time/ at the National Academy of Design/ in New York./ Eaton went to Paris in 1872/ where he studied at/ the Ecole des beaux arts/ and became a disciple of Millet./ On his return to New York in 1876,*/ he taught at Cooper Union./ His most famous landscape painting,/ Harvest Field,*/ was painted in France/ in 1883/ and was well-received/ on both sides of the ocean./ Eaton was influenced by/ a variety of nouveau, impressionist painters/ and his paintings reflected this/ without being derivative.*/ Eaton is best known however/ for his portraits of/ a variety of famous people,/ both Canadian and American./ He was/ the most sought-after portraitist/ of that time./ His initial commission,/ a series of pen and ink portraits/ of famous American poets,/ brought him widespread recognition./ Eaton went on/ to paint such notaries as/ William van Horne,/ Sir Donald Smith,/ William C. MacDonald,/ and Lord Mount Stephen./ Additionally,/ Eaton was the founding member/ and president/ of the American Art Association*/ and the Society of Canadian artists./

Eaton spent/ his last working years in Ottawa,/ and died in 1896./

Passage 113: Modern Dance

Modern dance is/ a variant of dance in which*/ the dancer moves and gyrates/ to the beat/ of the music./ Modern dance appears/ in many dance forms,*/ including the Twist, the Worm,/ the Pogo, Disco, and Be-bop,/ and is often performed/ in clubs and cabarets./ New dances are often made popular/ when well-known entertainers/ or other public figures/ endorse them through association./ For instance,/ performers such as John Travolta/ and the Village People/ contributed to the popularity of Disco/ in the 1970s./ The popularity/ of the genre/ seems to be unaffected*/ by trends toward/ revival of traditional dance forms./ Modern dancers,/ although nominally in pairs,/ tend not to touch/ while dancing/ and often perform/ completely different moves./ The dance focuses on/ the body movements/ of the dancers*/ as they gyrate/ to the music./ In the United States,/ modern dance has dominated/ the dance scene/ since the late 1950's/ when rock-and-roll music became popular.

Passage 114: Clog Dance

Clog dancing is/ a variant of dance in which*/ the dancer accentuates/ the rhythm of his feet/ by wearing wooden shoes, or clogs./ Clog dancing appears/ in many dance forms,*/ including some bourees in Auvergne,/ in Swiss landler,/ and often in Irish step dances/ such as solo jigs, reels and hornpipes./ In Northern England,/ notably among the miners of Northumbria and Durham,/ dances such as the Lancashire and Liverpool hornpipes/ may be danced on tabletops./ Wearing clogs,/ the dancers do their best/ to win prizes offered/ by the pub owners. The popularity/ of the genre/ seems to be unaffected*/ by trends toward/ modern dances. Like the Irish step dancers,/ English clog dancers maintain/ an expressionless face,/ motionless torso and arms./ The dance focuses/ on the feet/ of the dancers*/ as they beat complex rhythms./ In the United States,/ English and Irish clog dancing influenced/ the development of tap dance,/ America's only indigenous dance form./

Passage 127: German Shepherd Dog

The German shepherd dog/ was originally developed/ from herding dogs/ in Germany. It is a medium-sized/ but powerful dog/ with a large head/ and strong shoulders. The coat may be/ black and tan,*/ gray, or solid black,/ with coarse outer fur/ and a shorter softer inner coat. German shepherds stand/ 24 inches tall/ and weigh about 75 pounds. The dogs are known/ for their intelligence,/ alertness, and loyalty. They are often used*/ as army dogs,/ police dogs,/ or as guides/ for the blind/ because of these attributes. Shepherds are/ known as Alsations in Britain,/ and are one of the most popular/ of all breeds. In the U.S.,/ they are/ the second most commonly owned/ purebred dogs, after poodles. Shepherds, like all dogs,/ belong to the family Canidae,/ along with/ wolves and jackals. Features shared/ with other canidae/ that are prominent/ in shepherds/ include powerful jaws,/ teeth adapted for seizing,/ keen

senses of smell and hearing,/ and a strong social instinct. These characteristics/ have been adapted/ to produce a dog/ valued both*/ as a watchdog and a companion. German Shepherds seem to have/ a high capacity/ for developing motivation and attention*/ toward their handlers,/ which makes them able/ to absorb complex training. One task at which they excell/ is the demanding job/ of guide dog for the blind,/ probably because of/ the combination of traits mentioned.

Passage 118: Hoatzin

The hoatzin/ is a bird/ found in/ the vegetation/ lining the rivers/ of northern South America. It has a bristly crest/ on its head,/ a long tail,/ and a short curved bill. The body is brown/ spotted with white,*/ the crest is reddish brown,/ and the facial skin is/ a brilliant blue. Hoatzins grow/ to two feet in length/ and weigh about 28 ounces. In the chick,/ the first and second digits/ extend to a powerful claw. The claws are used*/ for climbing about/ in tree branches/ and give the young hoatzins/ a primitive, reptilian appearance. The young hoatzins/ will also dive and swim/ if danger threatens them/ near water. Old hoatzins, however,/ avoid water entirely/ and in fact almost never/ touch the ground. Hoatzins eat/ the leaves, flowers, and fruits/ of mangroves. An extremely large/ muscular crop/ is used/ for breaking up the food;/ this function/ is performed by the gizzard/ in other birds. Hoatzins nest/ in groups/ of ten or more birds,/ building flat nests*/ made of twigs. During breeding season,/ hoatzins form groups/ consisting of three to six birds*/ that mate and share parental duties,/ functioning almost like/ an avian commune. The hoatzin/ has no close relatives,/ but recent biochemical studies/ have suggested/ that it may be/ a highly aberrant cuckoo.

Passage 119: Modern cosmetics

Cosmetics have been popular/ as personal adornments/ at least since Roman times./ However,/ the fact that skin creams/ and similar products/ can now be included under cosmetics*/ reflects a major change/ in public attitudes./ The basic step/ in skin beautification/ is cleansing,/ and soap and water/ is still one/ of the most effective means./ Skin care products fall/ into four general categories./ These include/ cleansing creams and lotions,/ emollients,/ hand creams and lotions,/ and finally, a catchall category/ that includes speciallized products/ that are often designed for/ very specific skin conditions/ or purification needs./ Cleansing creams and lotions are used/ to remove heavy makeup*/ or on skin/ that is sensitive to/ the ingredients in soap./ Cold cream,/ one of the oldest beauty aids,*/ was originally composed of/ water beaten into/ some hard fatty substance/ such as lard./ Emollients are heavier derivatives*/ of cleansing creams/ that are usually formulated/ to require a massaging action./ Hand creams and lotions are used/ to prevent the roughness and dryness/ caused by exposure to/ wind, dry atmospheres, or chemicals./ Finally,/ the specialized skin care products include/ toners and fresheners that contain alcohol/ as well as ingredients/ that act as astringents and

germicides./

Passage 120: Roman Cosmetics

Cosmetics have been popular/ as personal adornments/ at least since Roman times./ By the time/ Nero became emperor/ in AD 54,/ both cosmetics and perfumes had assumed*/ an important role at court./ He personally used cosmetics liberally,/ and his wife,/ Poppaea,/ made no secret of/ using artificial beauty aids./ White lead and chalk were used/ to whiten the skin./ Egyptian kohl was used/ on the eyelids and lashes;/ fucus, a sort of rouge,/ for the cheeks and lips;/ psilotrum, a species of depilatory;/ barley flour and butter as/ a cure for pimples and skin eruptions;/ and pumice stone/ for whitening the teeth./ The ultrafashionable ladies/ of the Roman court*/ devised a method of/ bleaching their hair/ by means of a soap/ that came from Gaul./ The Romans made/ many attractive containers*/ for their perfumes and cosmetics./ The three principle kinds were*/ (a) solid unguents,/ (b) liquid unguents,/ and (c) powder perfumes./ The solid unguents were generally/ of one specific perfume/ such as almond,/ rose, or quince./ The liquid unguents were most frequently/ compounds of flowers, spices, and gums/ digested in/ olive, ben, or sesame oil./

Appendix 1b

Passages Used in Experiment 2

Notes: (a) / indicates phrase breaks

(b) A and B refer to the location of the interruptions.

(c) verification words are highlighted and appear after the appropriate phrase.

(d) Odd numbers were assigned to familiar passages and even numbers to unfamiliar passages. Familiar/unfamiliar pairs are contiguous.

Passage 205: Canadian Constitution

Canada is/ an independent/ federal parliamentary state. Since 1867,/ the main document/ of the Canadian Constitution/ has been/ the British North America (BNA) Act. The original set of resolutions,/ agreed upon by Canadians/ but made law/ **law**/ by the Parliament/ of the United Kingdom,/ created a new nation/ out of three colonies,/ New Brunswick, Nova Scotia, and Canada/ (what is now Ontario and Quebec)./—B—/ The BNA Act defines/ the most important elements/ of the federal system,/ including the major institutions/ of Parliament/ and the Provincial Legislatures,/ and the powers to be exercised/ by Canada's federal and provincial governments. The original BNA Act is, however, / **paper**/ only a part/ of the complete constitution./—A—/ Over the years/ the British Parliament has made/ more than 20 amendments/ to the act,/ usually at the request/ of the Canadian Parliament,/ and these became part/ of the Canadian Constitution. A number of purely Canadian laws/ touching on constitutional matters/ and contributing to/ the political evolution/ of our country/ have also become part/ of the overall Constitution./—B—/ These include/ the Canada Elections Act,/ and the federal statutes that created/ the provinces of Manitoba, Saskatchewan, and Alberta.

The strange situation/ of having our Constitution/ **Constitution**/ an Act of a foreign government/ remained a nagging problem./—A—/ Although a fully independent nation/ in other respects,/ Canadians could not amend/ their own Constitution/ without approaching the British Parliament./—B—/ Efforts to correct this situation/ began over 50 years ago,/ when Britain recognized/ the independence of Canada/ and other dominions/ with the passage/ of the Statute of Westminster in 1931. Two federal-provincial conferences,/ held in 1927 and 1931,/ failed to establish a formula/ that allowed all constitutional changes/ to be made in Canada. So, our Parliament asked Britain/ to keep its authority/ to amend the BNA Act./**document**/ There were more attempts/ in the years that followed,/ and on two occasions/ the eleven governments/ came close to agreement,/ but the breakthrough remained elusive.

Finally, new talks began/ in the summer of 1980/ at the time of political commitments/ by the government/ to constitutional reform. /--B—/ Agreement was reached/ between the federal government/ and nine of the ten provincial governments/ on the terms of patriation. In December of 1981,/ the House of Commons and the Senate/ **office**/ approved a Joint Address/ to Her Majesty the Queen/ requesting patriation/ of the Canadian Constitution./—A—/ In the United Kingdom,/ the British Parliament passed the Canada Act/ on March 25, 1982./—B—/ It did two things. First, it ended Britain's power/ to legislate for Canada,/ and second,/ at the same time/ it included our Constitution,/ the Constitution Act 1982. Its proclamation in Canada/ was the final step/ in the patriation process.

The BNA Act however/ is not dead./—A—/ The Constitution Act 1982/ states clearly/ that the BNA Act/ is still part of our constitution/ and it adds/ some important new provisions. These

include/ the Canadian Charter of Rights and Freedoms,/ new powers over natural resources/ of the provinces,/ and a written commitment/ to the well-established principle/ **principle**/ of making federal equalization payments/ to the less wealthy provinces.

Passage 206: Indian Constitution

India is/ a sovereign democratic republic. The constitution of India,/ which came into effect/ on January 26, 1950,/ is the lengthiest written constitution/ in the world. It contains much that/ in other countries/ is to be found/ in statutory rather than in constitutional law,/ **law**/ partially because of/ the attempts of the people/ responsible for the constitution/ to account for/ all possible situations./—B—/ It was promulgated/ on the day/ that India was proclaimed/ a republic,/ the first republic/ to achieve membership/ in the Commonwealth/ and the first to acknowledge/ the British monarch/ as head of that organization. This arrangement has undergone/ **paper**/ several revisions./—A—/ Changes or amendments/ to the constitution/ usually occur/ following landmark decisions/ by India's supreme court. The constitution has been described/ as a quasi-federal document/ providing for a unitary state/ and having subsidiary federal features,/ rather than a federal constitution/ with subsidiary unitary features./—B—/ This form was thought to provide/ the best arrangement/ for India's particular combination/ of loosely connected regions,/ that differ on many dimensions.

India's constitution derives/ **constitution**/ from several sources,/ but was mainly influenced/ by the British concept/ of parliamentary government./—A—/ The US constitution/ of the federal supreme court was adopted,/ and the American definition/ of certain presidential powers/ also influenced/ the final document./—B—/ The Indian president, however,/ functions more as a constitutional sovereign,/ primarily a ceremonial figurehead,/ than as the chief executive/ of the government./—A—/ Other sources for the constitution/ included the Canadian constitution,/ upon which India based/ its quasi-federal system,/ and the Irish constitution,/ to which its directing principles/ owe much. The constitution was/ an attempt to incorporate/ the best of the existing systems./ **document**/ However, the basic framework/ of the Indian constitution/ comes from/ the Government of India Act,/ which was enacted in 1935/ by the British Government.

The India Act actually contained/ no constitutional principles,/ rather, it was primarily/ a lengthy collection/ of administrative details./ B/ The Act created/ an elaborate federal structure/ in an attempt to unite/ the disparate regions/ in an equitable way. It was designed/ as the last installment/ of British influence /**office**/ before the assumption/ of full self-government/ which some British politicians expected/ would occur very soon./—A—/ This process was delayed/ by the outbreak of World War II/ and it was not until the Japanese/ began to pose a threat/ that the Indian situation/ again held Britain's attention. Independence for India was hampered/ by a number of factors./—B—/ Because India is composed of/ a very diverse collection/ of various linguistic and religious groups,/ agreement on

a unity policy/ was difficult. For instance, the creation of Pakistan and India,/ rather than one country,/ seemed the only alternative/ to civil war.

India is/ a federal union of states./—A—/ It has a strongly centralized national government,/ run by the prime minister and Cabinet/ who are elected representatives. Broadly, the distribution of powers/ between the centre and the states/ follows the accepted principle/ **principle**/ that the centre administers/ those matters which concern all of India,/ such as defense and foreign affairs,/ and other matters/ such as the police, public health, and education/ are administered by the individual states.

Passage 207: Microwave Ovens

Defrosting, reheating,/ and cooking food/ can be easily/ and quickly accomplished/ by modern microwave ovens. A microwave is simply/ an insulated box/ that subjects food/ to high energy waves,/ sometimes called/ superhigh frequencies./**device**/ These waves are termed 'micro'/ because of their extremely short wave lengths,/ shorter than radio waves/ but longer than infrared./—B—/ The microwaves penetrate the food/ and increase the overall energy level/ of each individual molecule,/ causing them to vibrate/ at a higher rate./—A—/ In spite of the simplicity/ of the basic process,/ microwaving is/ complicated by such concerns as:/ optimal energy levels,/ length of treatment, rotation,/ or stirring of food. The correct combination of factors/ **combination**/ should be sufficient/ to adequately cook/ just about anything. Browning food is probably/ the only thing/ the average microwave/ does not do well.

The designers of/ a new microwave/ must decide what functions/ **machine**/ to give the oven./—A—/ Usually, they would start/ with the most basic functions,/ such as time or energy level,/ and continue adding/ more complicated ones/ that are consistent/ with the oven's intended use/ and performance requirements. Because the basic functions/ are so simple,/ small microwaves are sold/ **dial**/ for quite low prices./—B—/ This simplicity/ also makes them/ easy to use. The simplicity does/ create problems however,/ in that it limits/ the usefulness and flexibility/ of the microwave,/ making it an addition/ to an already fully-equipped kitchen./—A—/ This view of a microwave/ as an 'extra'/ and therefore unnecessary/ can be addressed/ in a number of ways./—B—/ The most common include/ first, re-education/ (that is, teaching full use/ of the oven's capabilities)/ and second, loading the oven/ with features,/ allowing it to be used for/ just about everything.

The first technique/ for increasing the profile of microwaves,/ re-education,/ involves replacing/ people's current cooking methods/ and beliefs about cooking/ with new ones. The result may be/ a different and perhaps healthier/ cooking style. Vegetables, for instance,/ can be cooked quickly, neatly,/ and with minimal loss of flavour/ in a microwave./—A—/ In some ways,/ microwave cooking allows/ both greater freedom and more control/ over cooking/ and is a boon/ for the busy working couple. Heating up of leftovers/ or of

precooked food/ becomes painfully simple./—B—/ Re-education into/ the art of microwave cooking/ may have a profound impact/ on the eating habits/ of Western society.

The other method/ **method**/ of increasing the appeal/ of microwave cooking/ has been to add/ numerous extra features./—B—/ Ovens that combine/ both traditional convection/ (that is, hot air) cooking/ and microwaves/ have been developed. Such ovens can,/ for instance,/ be used either as a regular oven,/ as a microwave,/ or a strange mixed beast,/ in tandem or in series./—B—/ These newest products/ become multipurpose appliances,/ especially when/ a variety of other features are added. The goal here is/ **goal**/ to make the microwave/ central to kitchen operations.

Both these methods/ are widely used./ **used**/ For day-to-day purposes however,/ it seems unlikely that microwaves (even the super-deluxe models)/ are replacing the traditional oven./—A—/ Most houses still boast/ a traditional oven,/ whereas microwaves are considered/ to be an extra/ or a luxury. Unless some major change/ in available resources or lifestyles occurs,/ the microwave will probably never/ **steel**/ completely replace the traditional oven. The added convenience/ of a microwave/ will continue to make them popular sellers, however./-—A—/ In other words,/ most people who can afford it/ will buy a microwave,/ but they are unlikely/ to throw out/ their traditional oven.

Passage 214: GBX-64K Microline Point Plotter

Display of complex images/ can be easily and quickly accomplished/ by a GBX-64K Microline point plotter. This point plotter is simply/ a specialized circuit board/ designed to store images/ and transfer them/ to a display unit./ **device**/ The point plotter has a buffer/ where the coordinates/ of one or more/ three-dimensional arrays of points/ can be stored./—B—/ The points are moved/ through digital-to-analog converters/ to an oscilloscope/ at high speed/ without the intervention/ of the main computer./—A—/ Because of the simplicity/ of the basic process,/ the points can be/ plotted and refreshed/ at the rate/ of 20,000 per a ten millisecond cycle, which is extremely fast. The correct combination/ **combination**/ of point plotter,/ oscilloscope,/ and a computer/ produces optimal results. Plotting images/ and even producing animation/ become simple and efficient.

The designers of systems/ used in vision research/ are faced with/ **machine**/ a number of issues./—A—/ Usually, speed of plotting/ must be optimized,/ although the resolution of the image/ that is produced/ and the complexity/ of the image/ are also important to maximize/ within the intended use/ and performance requirements. A simple, inexpensive system/ consisting of a microcomputer/ and a television or video screen/ **dial**/ does not optimize resolution,/ complexity,/ or speed./—B—/ However, simple systems are inexpensive/ and easy to use. Larger computers constitute one way/ of addressing the speed,/ complexity,/ resolution issue/ because they make/ the speed of processing/ (and therefore plotting)/ much faster./—A—/ The cost/ of large computers/ is a problem however,/ and the use/ of a

television screen/ will rarely be satisfactory./—B—/ An oscilloscope has/ many more possible screen plotting locations/ (4096 to the television's 525)/ resulting in a resolution/ that is 8 times better.

Thus, replacing the standard video screen/ with an oscilloscope/ will improve resolution,/ and using a larger computer/ will increase speed of plotting. This combination does not solve/ the complexity issue though. The display hardware/ and the computer needed/ are still expensive,/ because speed of plotting is limited/ by the processing speed/ of the computer./—A—/ If the image/ must be displayed/ for an extended period of time/ without flicker/ then the image points/ must be replotted frequently. This requirement limits/ the total number of points/ that can be plotted/ in one cycle./—B—/ Thus, the complexity of the images/ that can be presented/ is greatly reduced.

The method used/ **method**/ in the GBX-64K device/ to overcome these problems/ is to increase/ the plotting speed/ by using a digital electronic circuit board./—B—/ The board makes/ the display of complex images possible/ with much less expensive computers. The point plotter has a buffer/ that stores the coordinates/ of an image array,/ and can in fact/ store up to three images/ at the same time./—B—/ As was mentioned,/ the point plotter can transfer/ these stored points/ to the oscilloscope/ much more quickly than/ the computer can. The goal here is/ **goal**/ to provide a high-speed interface/ between the computer and the display.

The buffer method/ has not been widely used./**used**/ However, for certain vision research purposes,/ it seems to be/ the ideal solution/ to the speed, complexity, resolution issue./—A—/ Images can be produced/ that are comparable to/ (or better than)/ those done with/ an expensive high speed computer/ that does not have/ the GBX-64K interface. The device is specially designed/ to take advantage/ **steel**/ of the timing requirements/ of certain vision research paradigms. The time between image presentations/ can be used/ to transfer the next plot/ to the buffer,/ from which it is easily and quickly plotted./—A—/ In other words,/ the GBX-64K Microline point plotter/ provides a simple and relatively inexpensive way/ to accomplish sophisticated image processing tasks.

Passage 209: University of Alberta

The University of Alberta is/ a large, publicly supported,/ coeducational institution/ that was authorized/ by the province in 1906. The sponsor of the bill/ was A. C. Rutherford,/ **classroom**/ Alberta's premier/ and first Minister of Education./—A—/ Classes opened/ in September of 1908/ in what is now Queen Alexandra School/ with 45 students/ and a faculty of 5. The first building on campus/ was Athabasca Hall,/ which opened in 1911./—B—/ Athabasca served/ as a residence/ for staff and students,/ included classrooms,/ laboratories,/ the library,/ a gymnasium,/ and the adminstration offices. The student body/ of the fledgling institution/ grew rapidly up until 1914,/ when the first World War/ broke out. The University sent/ **University**/ 438 of its staff and students/ to the armed forces.

After the War,/ requirements/ the University expanded rapidly./—A—/ Many departments/ (that have since become faculties)/ such as Agriculture,/ Accounting (now Business),/ Pharmacy,/ and Home Economics/ were added around this time. During the depression,/ enrollment held steady/ but the budget actually decreased,/ making it a difficult time financially. During the second World War,/ the University geared up/ to contribute/ to the war effort. Medicine, Dentistry, and Education/ offered accelerated courses/ marks/ and Engineering offered special courses/ to members of the armed forces. After the war,/ enrollment swelled/ with the flood of returning veterans, from 2,000 to about 5,000./—B—/ Accomodation in classrooms, labs, and libraries/ was pathetically inadequate,/ and there was also a shortage of staff. Growth continued,/ but more slowly,/ during the fifties.

In the sixties,/ enrollment had reached about 17,000,/ and this huge population necessitated/ the rapid construction/ desk/ of many new buildings,/ including the Lister Hall residence complex,/ Cameron library,/ the Physical Education building,/ the Education building,/ the Physical Sciences building,/ Tory Lecture,/ and the present Student's Union building. Recently, growth and expansion have slowed/ in these difficult economic times./—A—/ However, the University is still/ one of the largest in Canada.

The University of Alberta is/ a collection of various faculties/ that offer undergraduate degrees/ undergraduate/ and (often) graduate training./—A—/ For instance,/ the Faculty of Education trains teachers (BEd),/ Faculty of Science awards the BSc.,/ and the Faculty of Arts the BA./—B—/ In many cases though,/ students in one faculty/ take courses offered/ by other faculties/ as part of their degree requirements,/ for example,/ Engineering or Nursing students/ may take courses/ in the faculties of Arts (such as English)/ or Science (such as Psychology)./ degrees/ Students in the general BSc or BA programs/ are not usually allowed/ to take courses/ courses/ from other faculties/ when those courses are part of/ the requirements for quota degrees.

Like other institutions,/ the University of Alberta has/ its own traditions/ traditions/ and official symbols. In addition to the school motto/ (Quacumque Vera),/ a crest, and a coat of arms,/ the university has/ official academic costumes/ (that is, the gowns worn at Convocation)/ for the various degrees./—B—/ These costumes/ (gowns and hoods)/ were once required apparel/ at universities like Oxford or Cambridge. The official university colours,/ green and gold,/ were suggested/ by the autumn colours/ of the river valley/ below the campus./—A—/ The green represents/ 'wide stretches of prairie flanked by spruce forests'/ and symbolizes hope and optimism./—B—/ The gold represents/ 'golden harvest fields'/ and symbolizes the light of knowledge. The University of Alberta is/ a well-established university/ with a tradition/ of excellence and scholarship,/ excellence/ whose alumni people the ranks/ of Canadian politicians,/ scientists, educators, and professionals.

Passage 210: Harvard

Harvard University,/ established in 1636,/ is one of the oldest and foremost/ American educational institutions. Harvard's history/ dates from the establishment/ **classroom**/ of a college at New Towne./—**A**—/ New Towne was later renamed Cambridge/ after the alma mater/ of some leading colonists. Classes began/ in the summer of 1638/ with one master/ in a single frame house./—**B**—/ Harvard was named/ for a Puritan minister,/ John Harvard,/ who left the college his books/ and half of his estate. At its inception,/ Harvard was under church sponsorship/ and therefore, church control. During its first two centuries,/ **requirements**/ Harvard was gradually liberated/ first from clerical/ and later from political control.

The university has had some influence/ **university**/ on the course/ of American history./—**A**—/ The alumni and faculty/ of Harvard/ have been associated/ with many areas/ of intellectual and political development. By the 1960's,/ Harvard had educated/ six U.S. presidents,/ as well as justices,/ cabinet officers,/ and congressional leaders. Literary figures/ among Harvard alumni/ have counted Emerson,/ Thoreau,/ Eliot,/ and Henry James. In the mid-19th century/ Harvard's Lawrence Scientific School/ contributed to the growth/ **marks**/ of American applied science. William James introduced/ the experimental study of psychology/ to the United States/ at Harvard in the 1870's./—**B**—/ For private institutions like Harvard,/ it is often necessary/ to cultivate affluent or influential alumni. Harvard is fortunate/ in having/ a very distinguished group of sponsors.

In the last century,/ Harvard has been/ in the forefront/ **desk**/ of curricular innovation. During his term/ as Harvard's president (1869-1909),/ Charles Eliot made Harvard/ into an institution/ with national influence,/ and began the ongoing debate/ about the kind of education/ that will form/ educated, knowledgeable, and competent/ men and women./—**A**—/ He introduced/ an elective system/ to replace/ the old, rigid, classical curriculum.

At this time,/ undergraduates began to specialize/ **undergraduates**/ in their own area of interest/ and by 1894,/ only rhetoric and modern language/ were required subjects/ for college freshmen./—**A**—/ Ideas about education/ have undergone considerable change/ in the last century./—**B**—/ By the 1940's,/ a backlash against/ the elective system/ was well underway/ and a group/ of 'New Humanist' philosophers/ led by Irving Babbitt/ were calling for/ a renewed emphasis/ on liberal education/ according to the classical model./ **degrees**/ Throughout the sixties,/ departments interpreted core demands/ very permissively,/ and then in the seventies,/ the pendulum seemed to/ swing back to the earlier view/ that certain core courses/ **courses**/ are a necessary part/ of a complete education.

Like other institutions,/ Harvard has/ its own academic requirements, traditions,/ **traditions**/ and official symbols. At present,/ the core curriculum requires undergraduates/ to complete basic studies/ in five areas before specializing./—**B**—/ Harvard is/ a

member of the Ivy League,/ a group of colleges and universites/ in the northeastern United States/ regarded as/ high in academic and social prestige. These institutions include/ Yale, Pennsylvania, Princeton,/ Columbia, Brown, Dartmouth,/ and Cornell./—A—/ Together, they form/ an athletic conference/ for intercollegiate football/ and other sports./—B—/ The campus,/ which covers a large area/ in Cambridge, Mass./ (a suburb of Boston),/ is renowned for/ its classic period architecture. Harvard is/ a well-established university/ with a tradition/ of excellence and scholarship,/ **excellence**/ whose alumni people the ranks/ of American politicians,/ scientists, educators, and professionals.

Passage 211: Western Marriage

Marriage,/ the joining together/ of a male and a female/ into some relatively permanent union,/ varies considerably/ in form and customs/ from one culture to another./ Although similarites exist/ at a global level,/ there are legal,/ cultural,/ and ceremonial components/ that differ greatly./ In Canada and the United States,/ weddings are often/ large formal affairs,/ and the recent revivial/ of this custom/ has created/ a large entreprenurial wedding industry./ Legally, marriage in North America/ **marriage**/ involves three steps./—A—/ First, the interested parties/ (that is, the groom and the bride)/ agree in principle/ to the marriage,/ and then fix the date/ for the wedding./—B—/ The next step is/ to obtain the marriage license/ from the local government offices. In essence,/ for a nominal fee,/ they are registering their intent/ to form/ a legally binding union./—B—/ The acts of getting engaged,/ buying an engagement ring/ and all the attendant rituals/ are purely cultural,/ not legal, events./ **ceremony**/

The next step/ of the legal contract/ **contract**/ involves the marriage ceremony itself,/ conducted by/ a marriage commissioner or clergyman. The clergyman,/ the bride and groom,/ and two witnesses/ sign the marriage license/ and the union is/ official, legal, and binding./—A—/ The accompanying ceremonial aspects and rituals,/ although certainly linked/ to the legalities/ in the minds/ of the participants,/ are quite optional/ in terms of the law.

In North America,/ the full-fledged wedding rituals/ **flowers**/ vary somewhat/ with the culture/ of the participants./—B—/ In general,/ after the engagement is/ announced to the family,/ the parents may publish/ a formal statement/ in the newspaper,/ and the preparations begin./—A—/ Arrangements are made/ for the actual ceremony/ (usually performed in a church),/ a hall is reserved,/ and guest lists are compiled. Next, engagement parties,/ pre-wedding showers,/ and other events are held,/ **carriage**/ special outfits purchased,/ and invitations are sent. On the big day itself,/ the bride and groom prepare separately,/ **reception**/ meeting at the altar/ where the bride is delivered/ by her father/ into the keeping/ of the groom./—A—/ The exchange of rings,/ the post-nuptial reception,/ and the bride's adoption/ of her husband's last name/ are all quite optional.

A marriage that excluded/ the traditional rituals/ **rituals**/ would be considered/ legally binding,/ given that the afore-mentioned legal steps/ had been accomplished./—B—/ However, in the eyes/ of the family and friends/ of the nuptial pair,/ the rituals serve/ to publically establish/ their new status. The marriage rituals/ link the couple/ into a vast network/ **network**/ of beliefs, traditions, and expectation/ that forms the cultural fabric/ of their lives.

Passage 212: Bantu Marriage

Marriage,/ the joining together/ of a male and a female/ into some relatively permanent union,/ varies considerably/ in form and customs/ from one culture to another./ Although similarites exist/ at a global level,/ there are legal,/ cultural,/ and ceremonial components/ that differ greatly./ The Bantu of Southern Africa,/ whose currency is mainly/ in the form of cows,/ are an example/ in which the legal and symbolic aspects/ of marriage/ have become almost inseparable./ Legally, marriage among the Bantu/ **marriage**/ involves three steps./—A—/ First, the interested parties/ (that is, the groom and his family,/ and the bride's family) meet,/ agree in principle/ to the marriage,/ and then fix the bride-price/ or lobolo./—B—/ Interestingly, this dowry is quite different/ from that commonly found in/ some other cultures./ Among the Bantu,/ the groom pays/ for the bride,/ rather than the bride/ bringing a dowry/ into the marriage with her./—B—/ Because the Bantu are polygamous,/ this practice tends to insure/ that only men/ who can afford numerous wives/ will actually acquire them./ **ceremony**/

The next step/ of the legal contract/ **contract**/ involves the delivery/ of the lobolo,/ usually a specified number of cows/ and the final step/ is the delivery/ of the bride/ to the groom's kraal. When these steps are completed,/ the marriage,/ or customary union/ in the white-imposed legal terminology, /is official, legal, and binding./—A—/ The accompanying ceremonial aspects and rituals,/ although certainly linked/ to the legalities/ in the minds/ of the participants,/ are quite optional/ in terms of the law.

Bantu customs require that,/ before the bride leaves/ **flowers**/ her ancestral kraal,/ a cow is sacrificed/ and a feast is held./—B—/ The blood of the sacrifice/ is sprinkled over the bride/ and she is adorned/ with the bladder/ of the sacrificial animal./—A—/ This procedure symbolizes/ the bride's severance/ from her own family/ or ancestral tree. Next, the woman is 'twaaled'/ or formally abducted/ (according to specified customs)/ **carriage**/ and spirited away/ to the groom's kraal./ There, another cow is sacrificed/ and the bride is again adorned/ **reception**/ with the bladder/ to symbolize her union/ with her new family./—A—/ Another feast is held,/ and afterwards,/ the bride changes her dress/ and puts on a head scarf,/ indicating to the world/ that she is now/ a married woman.

A marriage that excluded/ the traditional rituals/ **rituals**/ would be considered/ legally binding,/ given that the afore-mentioned legal steps/ had been accomplished./—B—/ However, in the eyes of the family and friends/ of the nuptial pair,/ the rituals serve/ to

publically establish/ their new status. The marriage rituals/ link the Bantu couple/ into a vast network/ **network**/ of beliefs, traditions, and expectation/ that forms the cultural fabric/ of their lives.

Single-task verification

in two minutes/ The hungry bear felt/ redeemed the values/
For about a year/ despite the odds/ and almost returned alone.
sat on the rug/ The vicious circle/ the giant pounded mightly/
In the paradise/ Before it happened,/
distributed the wealth/ **laugh**/ dimly hinted at/
In fact, my best guess is/ in the district/ **jobs**/
rich in redundancy/ At first glance/ finalize the divorce.
reconstruction becomes important/ **reconstruction**/
large cars are bought/ **dole**/ to their own genders/
capitalize on/ On the contrary,/ often goes awry./
the remainder of the meal/ **districts**/ forms of behavior/
the classical ballets/ **ballets**/ of small islands/
Hopefully, the ugly dog/ The only kingdom/
to the affirmed existence/ **existence**/ as a shade of red/
limited amplitudes./ **symbol**/ half of the participants/
of the product/ not to be afraid/
in friendly towns or villages occurs/ **brain**/
over the records./ Without passion,/ to answer the question/
that almost certain victory/ **victory**/
into a polyglot mixture/ **mixture**/ conditions of defeat/
than hospitals permit/ at the end./
and expedition to the east/ **expedition**/
the sunrise over Tokyo/ the final act/ **act**/ carpets of moss./
of the empty parcel/ **story**/ refused arbitration./
encode new information/ on the ground/ The moon above is/ **moon**/
retrieved the receipt/ finely tuned sports car/
Small furry animals lurked/
its own posthumous dedication/ **dedication**/ The great debate/
one must assume/ the drums of war/
The giant dictionary of terms/ **dictionary**/
to capture changes/ and psychiatric epidemiology/
The president reconsidered/ of the noxious chemical/ **chemical**/
of the first edition/ all his options/
calculating his intelligence/ **intelligence**/
through the interpretation/ on the take./ **take**/
must conclude what friends/ **council**/ highly unlikely event/
behind the door/ are sometimes lost/ reflects our conviction/
The memory of warm fires/ The extra square/ **square**/
as special cases/ The department has had some leeway/ **department**/
The policeman went quietly/ the most important passages/ **details**/
from their mothers/ to destroy the house/ **resident**/
in defining concepts/ in sunnier climes/ Further evidence indicates/
the computer store and bakery/ **street**/ I will never see/
from the beginning/ **locations**/
Fundamentally, the practice is flawed/ **practice**/ the three bears/
was so lively/ During the past month,/ **circumstances**/
the actual path/ according to the best estimates./ **crystal**/
despite the intervention/ Using different procedures/
not cheerful, dreary./ **birthday**/ overrun with vermin/
The conventional level/ and other influences are subdued/ **compound**/
of the deceased/ they are three different structures/

Appendix 2

Familiarity Ratings of Experimental Passages

Mean Familiarity Ratings from Pilot Subjects for Passages Used in Experiment 1

passage	range	N	mean	s.d.		number of words
101	3-9	15	6.46	1.73		216
102	1-8	15	2.53	2.20	t(28) = 5.45	216
103	2-9	15	6.00	2.20		233
124	1-4	11	2.00	1.18	t(24) = 5.89	240
105	2-9	15	5.93	1.79		253
122	1-5	15	2.07	1.33	t(28) = 6.70	250
107	4-8	15	6.60	1.40		254
108	1-6	15	1.60	1.35	t(28) = 9.94	255
123	2-9	15	5.07	2.12		224
110	1-6	15	1.47	1.36	t(28) = 5.54	210
113	2-9	15	5.80	2.30		153
114	1-5	15	1.53	1.19	t(28) = 6.37	154
127	2-7	11	5.00	1.84		225
118	1-6	14	1.71	1.54	t(23) = 4.56	214
119	2-9	15	5.20	2.18		197
120	1-7	15	2.80	1.90	t(28) = 3.22	185
Mean	familiar		5.76	0.62		219
	unfamiliar		1.96	0.49	t(14) = 13.60	215

Mean Familiarity Ratings from Experimental Subjects
for Passages used in Experiment 1

passage	task*	range	N	mean	s.d.
101	S	6-8	10	7.1	0.57
101	D	2-9	10	7.0	1.94
102	S	1-6	10	3.0	1.89
102	D	1-5	10	2.8	1.69
103	S	1-7	10	5.2	1.93
103	D	3-8	10	5.0	1.94
124	S	1-6	10	2.3	1.83
124	D	1-5	10	2.3	1.64
105	S	3-8	10	5.9	1.66
105	D	3-9	10	6.6	1.84
122	S	1-8	10	2.3	2.21
122	D	1-4	10	1.8	1.14
107	S	3-9	10	6.8	2.21
107	D	1-8	10	5.7	2.16
108	S	1-6	10	1.9	1.91
108	D	1-3	10	1.2	0.63
123	S	2-8	10	4.7	1.95
123	D	2-7	10	4.2	1.62
110	S	1-4	10	1.4	0.97
110	D	1-5	10	1.6	1.26
113	S	1-8	10	5.0	2.54
113	D	3-8	10	5.7	1.70
114	S	1-7	10	3.3	2.26
114	D	1-7	10	3.6	2.22
127	S	3-9	10	5.8	1.93
127	D	4-9	10	5.9	1.45
118	S	1-4	10	1.6	1.08
118	D	1-6	10	2.2	2.10
119	S	2-9	10	5.2	2.04
119	D	1-7	10	4.2	1.81
120	S	1-7	10	2.8	1.81
120	D	1-7	10	2.9	2.13
Mean	single	familiar		5.7	0.86
		unfamiliar		2.3	0.67
	dual	familiar		5.5	1.02
		unfamiliar		2.3	0.78

* S are single-task ratings; D are dual-task ratings

Mean Familiarity Rating from Pilot Subjects for Passages Used in Experiment 2

passage	range	n	mean	s.d.		number of words
205	2-8	13	4.92	1.70		514
206	1-4	14	1.57	1.01	t(25) = 6.01	525
207	4-8	15	5.73	1.28		577
214	1-4	10	1.50	0.97	t(23) = 9.38	610
209	1-8	13	5.23	2.01		571
210	1-5	15	2.07	1.22	t(26) = 4.94	535
211	2-9	13	6.69	1.84		422
212	1-9	14	2.79	2.64	t(25) = 4.49	447
Mean	familiar		5.64	0.77		
	unfamiliar		1.98	0.60	t(6) = 7.50	

Mean Familiarity Rating from Experimental Subjects for Passages Used in Experiment 2

passage	range	n	mean	s.d.	
205	3-8	12	5.75	1.71	
206*	1-5	11	2.54	1.29	t(21) = 5.11
207	4-8	12	6.00	1.21	
214	1-5	12	1.75	1.36	t(22) = 8.09
209*	5-9	12	6.83	1.27	
210*	2-8	12	4.42	1.83	t(22) = 3.75
211	5-8	12	6.58	1.00	
212	1-4	12	2.17	1.40	t(22) = 8.88
Mean	familiar		6.29	0.50	
	unfamiliar		2.72	1.18	t(6) = 5.57

* Experimental rating significantly different than pilot rating

Appendix 3a

Comprehension Questions Used in Experiment 1

Passage 101

1. According to the passage, the factor or factors that contributed to Edmonton's slow growth rate before the second World War included:
   a. settlement did not start until 1870.
   b. its northern location and isolation.
   c. the routing of the CPR line through Calgary.
   d. the terrible climate and hostile populace.
   e. both a and b.

2. Edmonton was founded by_____in_____.
   a. eastern Europeans: 1870.
   b. the Northwest Company : 1795.
   c. the Hudson's Bay Company : 1795.
   d. the Hudson's Bay Company : 1870.
   e. American fur traders : 1795.

3. Recently, Edmonton has been characterized as:
   a. depressed and depressing
   b. an interesting and exciting place to live.
   c. empty of all historical interest.
   d. a busy, thriving port.
   e. a tiny, backwards northern community.

4. According to the passage, Edmonton's future is:
   a. hopeful.
   b. very dependent on the world economic situation.
   c. not likely to include anything that is good.
   d. similar to that of other large cities.
   e. likely to be undistinguished.

5. According to the passage, the construction of West Edmonton Mall:
   a. put Edmonton on the map.
   b. may attract shoppers from all over North America.
   c. has made Edmonton a shopper's nightmare.
   d. attracts very few Albertans to Edmonton.
   e. all of the above.

Passage 102

1. According to the passage, the factor or factors that led to the decline of Louisbourg included:
   a. lack of an ice-free harbour.
   b. inability to handle large ocean-going ships.
   c. the isolated location.
   d. the small and inhospitable populace.
   e. both a and b.

2. Louisbourg's early history included:
   a. a long and peaceful period of prosperity in the 18th century.
   b. a series of battles that led to the town's destruction.
   c. constant economic problems.

d. a reliance on British military power.
e. an active fish-processing industry.

3. Around the turn of the century, what products were shipped through Louisbourg?
   a. agricultural goods and raw materials.
   b. raw materials and industrial products.
   c. homemade crafts and forest products.
   d. forest products and industrial raw materials.
   e. agricultural, industrial, and forest products.

4. Louisbourg is in the_____of_____.
   a. state : New England.
   b. province : New Brunswick.
   c. state : New York.
   d. province : Nova Scotia.
   e. none of the above.

5. Louisbourg was built originally because of:
   a. the accessibility of coal and other raw materials.
   b. England's determination to oust the French presence in North America.
   c. its role as an industrial centre for North American industry.
   d. its strategic location for defense of France's empire.
   e. the scenic beauty of the area and strategic location of fishing grounds.

Passage 103

1. The modern typewriter keyboard is the same one that was used with early machines. According to the passage, why was this particular arrangement of keys developed?
   a. because studies indicated that it was the most efficient arrangement.
   b. because of the tendency for letters occurring sequentially in words to be typed too quickly and cause the typewriter to stop.
   c. because letters on the keyboard were too easily confused if they occurred in sequential or alphabetical order.
   d. both b and c.

2. The main advantages of computers over electric typewriters are;
   a. reduced cost, increased speed.
   b. reduced cost, easier editing.
   c. easier editing, increased speed.
   d. increased speed, decreased noise.
   e. increased cost, decreased speed, decreased noise.

3. What change probably had the biggest effect on the content of written material?
   a. the development of manual typewriters.
   b. the development of electric typewriters.
   c. the development of word processors.
   d. the development of penmanship.

e. none of the above.

4. What was regarded as a sign of modern thinking?
   a. using a word processor.
   b. sending typewritten documents.
   c. having an office staffed with expert typists.
   d. producing typewritten term papers.
   e. using a word processor to modify content.

5. What change probably had the biggest effect on the production of written material?
   a. the development of manual typewriters.
   b. the development of electric typewriters.
   c. the development of word processors.
   d. the development of penmanship.
   e. none of the above.

Passage 124

1. The term fraktur refers to:
   a. a group of Mennonites who originated the art.
   b. the appearance of the lettering.
   c. the religious significance of the lettering.
   d. both a and b.
   e. none of the above.

2. Anna Weber is notable among fraktur artists because;
   a. she drew animals and birds.
   b. she worked in the mid-20th century.
   c. she was female.
   d. a and c.
   e. none of the above.

3. Fraktur originated in:
   a. Europe.
   b. Pennsylvania.
   c. Ontario.
   d. certain counties in Ontario.
   e. Waterloo county.

4. Fraktur has recently be revived by:
   a. Mennonites who have rediscovered their heritage.
   b. people interested in folk art.
   c. southern Ontario school districts.
   d. a and b.
   e. a, b, and c.

5. According to the information given in the passage, fraktur seems to be mainly a form of:
   a. handwriting.
   b. illustrating.
   c. decorative calligraphy.
   d. a combination of b and c.
   e. a combination of a and c.

Passage 107

1. At the end of the_____season, Gretzky held individual records.
   a. 81-81; 37
   b. 81-82; 34
   c. 83-84; 37
   d. 83-84; 34
   e. 82-83; 37

2. According to the passage, Gretzky's talents have benefitted others than himself, including:
   a. Edmonton
   b. the Edmonton Oilers
   c. his father
   d. a and b.
   e. a, b, and c.

3. Gretzky's amazing talents were obvious:
   a. from the age of 19 when he joined a major league sports team.
   b. from the age of 17 when he joined a major league sports team.
   c. even when he was a young boy.
   d. to all except his peers.
   e. when the Edmonton Oilers joined the NHL.

4. The main criticism of Gretzky mentioned was:
   a. his lack of awareness of being a role model.
   b. his high and mighty attitude.
   c. his obsequiousness and triviality.
   d. his relatively non-controversial attitudes.
   e. his rudeness to the press.

5. One could infer that the writer of the passage
   a. is a fan of Gretzky.
   b. supports the development of minor hockey in order to produce more Gretzkys.
   c. believes that performance is remembered best.
   d. both a and c.
   e. a, b, and c.

Passage 108

1. At the end of the_____championship, Wan Po Li had won against all other players.
   a. 81-81; except the Grand Master.
   b. 81-82; in his age class.
   c. 83-84; except the Grand Master.
   d. 83-84; in his age class.
   e. none of the above.

2. According to the passage, Wan Po Li's talents have helped others than himself, including:
   a. the Japanese National Team
   b. the Chinese National Team

c. his father
d. a and b.
e. a and c.

3. The main criticism of Wan Po Li mentioned was:
a. his lack of awareness of being a role model.
b. his high and mighty attitude.
c. his obsequiousness and triviality.
d. his relatively non-controversial attitudes.
e. his absorption in the world of Go.

4. One could infer that the writer of the passage
a. is a fan of Wan Po Li.
b. support the advancement of the game of Go in North America
c. believes that performance is remembered best.
d. both a and c.
e. a, b, and c.

5. There was some suggestion in the passage that Wan Po Li was encouraged in his development by his parents. One could infer this from the reference to:
a. his support of many charities.
b. playing at school.
c. the young age at which he started playing.
d. playing every night.
e. both c and d.

Passage 123

1. Leonardo Da Vinci was born:
a. at Milan in 1452.
b. near Florence in 1452.
c. at Milan in 1481.
d. near Florence in 1481.
e. none of the above.

2. Da Vinci was apprenticed:
a. to an Italian sculptor in France.
b. to Andrea del Verrocehio.
c. at age 15.
d. to a French sculptor in Florence.
e. both b and c.

3. Da Vinci is a good example of a Renaissance man because:
a. he lived in the 15th century.
b. he was an artist.
c. he was scientifically inclined.
d. his interests were numerous and varied.
e. none of the above.

4. In addition to his knowledge of painting and sculptor, Da Vinci had considerable knowledge of:
a. engineering.
b. architecture.

c. politics.
d. a and b.
e. a, b, and c.

5. Which of the following maxims is best supported by Da Vinci's achievements:
a. hard work leads to gain.
b. education makes the man.
c. money knows no object.
d. genius is born, not made.
e. both b and d.

Passage 110

1. Wyatt Eaton was born:
a. at Quebec City in 1830.
b. at Quebec City in 1849.
c. at Philipsburg in 1849.
d. at Philipsburg in 1830.
e. in Ottawa in 1849.

2. In addition to the American Art Association, Eaton was responsible for:
a. the Society of Canadian Artists.
b. the Canadian Art Association.
c. the Society of American Artists.
d. the North American Art Association.
e. all of the above.

3. Eaton was considered to be
a. derivative of the famous impressionists.
b. a reasonable and fair art dealer.
c. the best portrait painter of modern times.
d. unsupportive of students.
e. none of the above.

4. Eaton's original project that vaulted him to recognition was
a. the painting Harvest Field.
b. his painting of William van Horne.
c. a series of pen and ink drawings of famous poets.
d. the establishment of the American Art Association.
e. none of the above.

5. According to the passage, Eaton is best known for:
a. the painting Harvest Field.
b. portraits of famous men.
c. a series of pen and ink drawings of famous poets.
d. the establishment of two Art Societies.
e. his association with Millet.

Passage 113

1. Would the jive be classified as a modern dance, according to the information given in the passage?

a. no because the dancers touch.
b. no because the steps are choreographed.
c. yes because it became popular in the fifties and was a favourite of early rock and roll fans.
d. yes because it focuses on body movements.
e. none of the above.

2. Modern dance focusses on
a. a series of carefully planned steps.
b. loud music.
c. body movements that interpret the music.
d. both a and b.
e. a, b, and c.

3. New dances often become popular when:
a. they are shown on television.
b. the media begins to report on them.
c. popular entertainers endorse them.
d. both a and c.
e. a, b, and c.

4. The main characteristic that distinguishes modern dance from other dance forms is probably:
a. the type of music that it accompanies.
b. it is individualistic.
c. it is not very widely practiced.
d. both a and b.
e. a, b, and c.

5. In the passage, it is implied that:
a. modern dance is popular only with young people.
b. modern dance really refers to twentieth century dances.
c. modern dance is primarily done in private.
d. modern dance is often by rock-and-roll music.

Passage 114

1. Would ballet be classified as a clog dance, according to the information given in the passage?
a. no because the dancers perform alone.
b. no because the footwear is different.
c. yes because both are descended from various folk dances.
d. yes because it focuses on body movements.
e. both a and b.

2. Clog dancing focusses on
a. a series of carefully planned steps.
b. loud music.
c. the feet beating complex rhythms.
d. both a and b.
e. a, b, and c.

3. Clog dancing seems to be a tradition:
a. in Europe, mainly.

b. in the British Isles.
c. in most of the world.
d. both a and c.
e. a, b, and c.

4. English clog dancers:
a. embellish the dance with intricate arm movements.
b. have little in common with other forms.
c. are rare.
d. both a and b.
e. none of the above.

5. In the passage, it is implied that:
a. clog dancing is popular only with young people.
b. clog dancing really refers to twentieth century dances.
c. clog dancing is often a component of other dances.
d. clog dancing is not accompanied by music.
e. none of the above.

Passage 127

1. German shepherd dogs are primarily:
a. black and tan
b. grey and black
c. solid black
d. a and b
e. a, b, and c

2. The dog is known for its:
a. independence.
b. intelligence.
c. determination.
d. strength.
e. ferocity.

3. German shepherds are known as _____ in Britain:
a. German pointers
b. Alsations
c. Aleutians
d. British shepherds.
e. none of the above.

4. German shepherds' ability to learn complex behaviors may be due to:
a. long breeding history
b. a high capacity for attachment to people
c. a tendency to fear their handlers.
d. a and c.
e. a, b, and c.

5. The features that shepherds share with wolves probably make them well suited to being:
a. house pets.
b. hunting dogs.
c. guard dogs.

d. show dogs.
e. none of the above.

Passage 118

1. On its head, the hoatzin has_____, and it has a _____tail.
   a. a crest : short
   b. a crest : long
   c. a crown of feathers : short
   d. a crown of feathers : long
   e. brown spots : a brown tail.

2. Young hoatzins (chicks) have a claw:
   a. on the third and fourth digits of the foot.
   b. on the second and third digits of the wing.
   c. protroding from the beak.
   d. on each toe.
   e. none of the above.

3. The claws are used for:
   a. defense against predators.
   b. climbing trees.
   c. breaking out of the eggs.
   d. both a and b.
   e. a, b, and c.

4. One of the major differences between the young and the old hoatzins is:
   a. the young avoid water; but the old are proficient swimmers.
   b. the old avoid water; but the young are proficient swimmers.
   c. young hoatzins are dark and drab in colour; old ones are brightly coloured.
   d. old hoatzins are dark and drab in colour; young ones are brightly coloured.

5. Hoatzins eat:
   a. seeds, leaves, and flowers from citrus plants.
   b. mangroves.
   c. mangoes.
   d. primarily fish.
   e. none of the above.

Passage 119

1. This passage was mainly about:
   a. cosmetics.
   b. skin care products.
   c. skin care practices.
   d. both a and b.
   e. a, b, and c.

2. One of the functions of cold creams that was mentioned was:
   a. makeup removal.
   b. cleansing of skin.

c. reduction of skin irritation.
d. combatting sun burn.

3. Cold cream originally consisted of:
   a. animal fats, such as lard.
   b. water and cream.
   c. water and fat.
   d. cream and fat.
   e. plant extracts and water.

4. Emollients are formulated to:
   a. replace cold creams.
   b. repair damaged skin.
   c. reduce skin irritations.
   d. require a massaging action.
   e. all of the above.

5. According to the passage, the basic step in skin care is:
   a. use of the appropriate products.
   b. washing with soap and water.
   c. careful balancing of skin products.
   d. using products for special applications.
   e. none of the above.

Passage 120

1. Cosmetics and perfumes were used by the Romans:
   a. up until 54 AD when Christianity became widespread.
   b. after 54 AD.
   c. during the decline of the empire.
   d. only on special feast days.
   e. none of the above.

2. Fucus is
   a. rouge.
   b. a depilatory.
   c. a cure for skin eruptions.
   d. a type of perfume.
   e. kohl.

3. Roman ladies did all of the following EXCEPT:
   a. whiten their teeth.
   b. lighten their hair.
   c. darken their eyebrows.
   d. remove unwanted hair.
   e. redden their cheeks.

4. Solid unguents were usually
   a. mixtures of spices, flowers, and gums.
   b. one specific perfume.
   c. suspended in oil.
   d. both a and c.
   e. none of the above.

5. One difference between the Romans' use of cosmetics and the use of cosmetics today that is implied by the passage is:
   a. the range of cosmetics was larger then.
   b. the types of perfumes are different.
   c. males seemed to use cosmetics more liberally then.
   d. females seemed to use cosmetics more liberally then.
   e. all of the above were implied.

Appendix 3b

Comprehension questions used in Experiment 2

Passage: 205

1. Politically, Canada is known as a:
   a. social democratic republic
   b. federal parliamentary state
   c. sovereign democratic republic
   d. sovereign parliamentary state
   e. federal democratic state

2. The constitution of Canada is distinguished because it is:
   a. modelled solely on the U.S. constitution.
   b. very comprehensive
   c. the longest written constitution in the world.
   d. the only orally transmitted constitution in the world.
   e. none of the above.

3. The BNA Act united the colonies of:
   a. Ontario, New Brunswick, and P.E.I.
   b. Ontario, New Brunswick, and Nova Scotia.
   c. Canada, New Brunswick, and Nova Scotia.
   d. Ontario, Quebec, and New Brunswick.
   e. Canada, New Brunswick, and Quebec.

4. In addition to the BNA Act, the Canadian constitution before patriation also included:
   a. the Canada Elections Act.
   b. the statutes that created Manitoba, Saskatchewan, and Alberta.
   c. amendments to the BNA Act by the Canadian parliament.
   d. both a and b.
   e. a, b, and c.

5. Efforts to patriate the constitution began:
   a. with the passage of the Statute of Westminister.
   b. shortly after Canada was created by the BNA Act.
   c. in the summer of 1980.
   d. both a and b.
   e. none of the above.

6. The Canada Act:
   a. is an Act of the Canadian Parliament.
   b. ended Britain's power to legislate for Canada.
   c. included the Constitution Act.
   d. both a and c.
   e. a, b, and c.

7. In addition to the BNA Act, the new constitution also includes:
   a. the Canadian Charter of rights and freedoms.
   b. reduced powers over resources of the provinces.
   c. a written committment to federal equalization payments.
   d. both a and c.
   e. a, b, and c.

Passage 206

1. Politically, India is known as a:
   a. social democratic republic
   b. federal parliamentary state
   c. sovereign democratic republic
   d. sovereign parliamentary state
   e. federal democratic state

2. The constitution of India is distinguished because it is:
   a. modelled solely on the U.S. constitution.
   b. very comprehensive
   c. the longest written constitution in the world.
   d. the only orally transmitted constitution in the world.
   e. none of the above.

3. India is unique because it:
   a. was the first republic in the commonwealth.
   b. is the only republic with a sovereign as head of state.
   c. was the only commonwealth republic that was created peacefully.
   d. both a and b.
   e. a, b, and c.

4. The Indian constitution was described as:
   a. providing for a strong federal state with subsidiary unitary features.
   b. providing for a unitary state with subsidiary federal features.
   c. providing for a strong unitary state with strong federal features.
   d. quasi-federal and weakly unitary.

5. Why was the Indian constitution created as described in the previous question?
   a. because of a relatively homogenous population.
   b. because of the diversity among regions.
   c. because of the lack of agreement among British officials.
   d. both a and c.
   e. none of the above.

6. The responsibilities of the Indian president are most like those of:
   a. the Governor-General.
   b. a chief executive.
   c. a prime minister (Canadian).
   d. a prime minister (British).
   e. the American president.

7. The document that the Indian constitution grew out of was:
   a. the Government of India Act of 1950.
   b. the Government of India Act of 1935.
   c. the Indian Constitutional Act of 1943.
   d. the Indian Independence Act of 1935.
   e. the American constitution.

8. The document mentioned above contains mostly:
   a. constitutional principles.
   b. administrative details.
   c. cultural preparations.
   d. both a and b.
   e. a, b, and c.

9. The constitution of India was an attempt to:
   a. emphasise regional disparities, but in an equitable way.
   b. unite disparate regions under an elaborate federal structure.
   c. provide an equitable distribution of wealth.
   d. allow for regional interaction with minimum cost.
   e. none of the above.

10. The government of India is run mainly by:
   a. the president and appointed cabinet members.
   b. the president and elected cabinet members.
   c. the prime minister and appointed cabinet members.
   d. the prime minister and elected cabinent members.

11. Would highways be under federal or regional control?
   a. federal.
   b. regional.
   c. both.
   d. neither.

Passage 207

1. The term 'micro' comes from:
   a. short wavelength.
   b. low frequency.
   c. small size of the oven.
   d. a trademark.
   e. both a and b.

2. The simplicity of microwave cooking is complicated by concerns about:
   a. optimal energy levels.
   b. length of treatment.
   c. original temperature of food.
   d. both a and b.
   e. a, b, and c.

3. The average microwave probably would not be useful for cooking:
   a. cookies.
   b. casseroles.
   c. frozen meat pies.
   d. cruciferous vegetables.
   e. fudge.

4. One method of re-education involves:
   a. selling microwaves to certain segments of the population (e.g., Yuppies).

b. stressing the low price.
c. pointing out the usefulness for defrosting and reheating foods.
d. teaching new techniques.
e. all of the above.

5. The other method involves:
a. adding a variety of functions.
b. stressing the low price.
c. teaching new techniques.
d. pointing out the usefulness for defrosting and reheating foods.
e. special deals on new ovens.

6. One of the most recent innovations was:
a. timed cooking.
b. delayed cooking.
c. combined convection and microwave cooking.
d. a browning function.
e. none of the above.

7. The theme of this passage is:
a. microwaves are wonderful.
b. everyone needs a microwave, whether they know it or not.
c. microwaves complement the well-equipped kitchen.
d. acceptance of new methods depends on changing attitudes.
e. cooking is a dying art.

8. Most people probably consider microwaves:
a. as a convenience, but not a necessity.
b. as a necessity.
c. as an extra appliance in a well-equipped kitchen.
d. too important to do without.
e. both a and c.

Passage 214

1. The GBX-64K device can be briefly described as:
a. a computer
b. an oscilloscope attached to a computer
c. a buffer attached to an oscilloscope
d. an interface
e. a high-speed number cruncher

2. Probably the most important aspect of plotting visual images is:
a. optimizing plotting speed
b. optimizing image resolution
c. optimizing image complexity
d. both b and c.

3. Which of the following components of a complete image processing puts the greatest limits on the complexity of the image that can be plotted:
a. the computer
b. the GBX-64K device
c. the display device

d. both a and b define the limits.

4. What is the main advantage of the GBX-64K device:
   a. it allows any computer and any display device to be used
   b. it increases the total number of points that can be generated.
   c. it can plot points more quickly than the computer.
   d. both a and c.
   e. both b and c.

5. Which issue is not addressed by using a large computer and an oscilloscope (instead of a T.V. screen):
   a. resolution
   b. complexity
   c. speed
   d. both a and b.

6. How many images can be stored by the point plotter at one time:
   a. one per refresh cycle.
   b. up to three.
   c. four to six.
   d. it depends on the computer processor.
   e. none of the above.

7. Why is the GBX-64K device particularily useful for vision research:
   a. because it can do animation.
   b. because it does not require a high-speed computer.
   c. because oscilloscopes are easy to use.
   d. because it can transfer plots to the buffer in between presentations of other images.
   e. all of the above.

8. The computer in this application is used primarily to:
   a. control plotting.
   b. direct the sequence of events.
   c. produce the coordinates of the points to be plotted.
   d. both a and b.
   e. both b and c.

Passage 209

1. Who sponsored the provincial act that authorized the creation of the University of Alberta?
   a. Queen Alexandra.
   b. Tory.
   c. Cameron
   d. Sheppard.
   e. Rutherford.

2. The first campus building was_____ which opened in_____.
   a. Athabasca; 1908.
   b. Pembina; 1908.
   c. Athabasca; 1911.
   d. Assiniboia; 1908.
   e. Assiniboia; 1911.

3. The first World War had what sort of effect on the operation of the U of A?
   a. none.
   b. small.
   c. moderate.
   d. large.
   e. not enough information.

4. The department of_____was added after World War I.
   a. Science.
   b. Arts.
   c. Pharmacy.
   d. both a and c.
   e. none of the above.

5. During World War II, the faculties of Medicine, Dentistry, and Education:
   a. offered special courses to members of the armed forces.
   b. offered accelerated programs.
   c. closed down because of the shortage of students.
   d. both a and b.
   e. none of the above.

6. During the enrollment boom of the sixties, which two buildings were built on campus:
   a. Cameron Library and Education.
   b. Physical Education and BioSciences.
   c. Education and Administration.
   d. Cameron Library and Administration.
   e. BioSciences and Administration.

7. What is the main difference between being in a quota faculty (such as Engineering) and being in a nonquota faculty (such as Science) that was mentioned in the passage?
   a. stricter admission requirements.
   b. smaller size.
   c. students in quota faculties can take courses in nonquota faculties, but the reverse is not usually true.
   d. Engineering is a job-oriented faculty, whereas Science is oriented towards providing a liberal education.
   e. all of the above were mentioned.

8. The official university colours, green and gold, symbolize:
   a. learning and achievement, respectively.
   b. hope and optimism and the light of knowledge.
   c. achievement and the light of knowledge.
   d. the autumn colours of Alberta.
   e. all of the above.

9. One similarity between present conditions on campus on those that existed after World War II include:
   a. growth of student population.
   b. abundance of funds.

c. overcrowding in classrooms and laboratories.
d. both a and b.
e. both a and c.

10. What was the Business faculty originally?
a. the department of Business.
b. the department of Accounting.
c. the faculty of Accounting.
d. the faculty of Finance.
e. it was always known as the faculty of Business.

Passage 210

1. Who was Harvard University named after?
a. the alma mater of some leading colonists.
b. the river that it is situated on.
c. a Puritan minister who donated his books.
d. a well-known colonist who donated half of his estate.
e. Harvard was the family name of the current King

2. Classes began:
a. in 1636
b. in 1637
c. in 1638
d. in 1639
e. in 1635.

3. When it first began, Harvard was under:
a. government control.
b. political control.
c. clerical control.
d. British control.
e. none of the above.

4. By the 1960's, Harvard had educated how many presidents?
a. four.
b. five.
c. six.
d. seven.
e. eight.

5. What school at Harvard has contributed to the growth of American applied science:
a. Lawrence Scientific School
b. Laurentian School of Science.
c. Harvard Science School.
d. the Science faculty.
e. none of the above.

6. Harvard has what advantage over other private schools:
a. a large trust fund from the original donors.
b. a rich undergraduate population.
c. a distinguished set of alumni.
d. both a and c.

e. a, b, and c.

7. What was Charles W. Eliot's contribution:
   a. he is a famous poet who went to Harvard.
   b. he was a president of Harvard.
   c. he standardized courses and brought back the fundamentals of education.
   d. he introduced an elective system.
   e. all of the above were mentioned.

8. In 1894, what subjects were required of college freshmen:
   a. modern language
   b. classics and science
   c. rhetoric
   d. both a and b.
   e. a, b, and c.

9. One gets the feeling from the passage that:
   a. Harvard has a rigid curriculum.
   b. views about the optimal education have undergone many changes over the years.
   c. education at Harvard is less important than learning.
   d. Harvard is out of step with other American institutions.
   e. all of the above.

10. The Ivy League refers to:
    a. the most prestigious colleges in the United States.
    b. a group of well-established publically supported institutions.
    c. an athletic conference.
    d. both and c.
    e. a, b, and c.

Passage 211

1. The two most important legal components of marriage in North America are:
   a. announcing intent and registering intent.
   b. announcing intent and signing the license.
   c. registering intent and signing the license.
   d. announcing intent and performing the ceremony.

2. Which of the following might be considered optional components:
   a. deciding on the date.
   b. buying an engagement ring.
   c. obtaining a license.
   d. both a and b.
   e. all of the above.

3. The definition of marriage used by this passage was:
   a. a legal definition.
   b. joining together two people into some relatively permanent union.
   c. a cultural definition.
   d. a contractual definition.

4. Wedding rituals common to North America that were mentioned in the passage include:
   a. a honeymoon.
   b. engagment parties and showers.
   c. purchasing and sending invitations.
   d. both b and c.
   e. a, b, and c.

5. What is the function of the cultural rituals?
   a. to make the marriage legally binding.
   b. primarily religious.
   c. to publiqally establish the new status of the couple.
   d. both a and b.
   e. a, b, and c.

6. If the minister forgot to sign the marriage certificate, but everything else had gone off smoothly, what would be the couples status, according to this passage:
   a. legally married.
   b. not legally married.
   c. married.
   d. none of the above.

7. The revival of the traditional 'white wedding' is probably most heartening for:
   a. the moral minority.
   b. traditional ministers and priests.
   c. entreprenieurs.
   d. parents.
   e. none of the above.

Passage 211

1. The two most important legal components of marriage for the Bantu are:
   a. fixing the lobolo and delivering the bride.
   b. delivering the bride and the lobolo.
   c. fixing and delivering the lobolo.
   d. killing a cow and delivering the bride.

2. Which of the following might be considered optional components:
   a. fixing the bride-price.
   b. slaughtering a cow.
   c. delivering the bride.
   d. deciding on the lobolo.
   e. all of the above.

3. The definition of marriage used by this passage was:
   a. a legal definition.
   b. joining together two people into some relatively permanent union.
   c. a cultural definition.
   d. a contractual definition.

4. Wedding rituals common to the Bantu that were mentioned in the passage include:
   a. ritual kidnapping.
   b. an extended honeymoon.
   c. sacrifice of a cow.
   d. both a and c.
   e. a, b, and c.

5. What is the function of the cultural rituals?
   a. to make the marriage legally binding.
   b. primarily religious.
   c. to publically establish the new status of the couple.
   d. both a and b.
   e. a, b, and c.

6. If the woman did not show up at the husband's kraal, but everything else had gone off smoothly, what would be the couples status, according to this passage:
   a. legally married.
   b. not legally married.
   c. married.
   d. none of the above.

7. The important difference between a Bantu bride-price and that common to some other (e.g., especially European cultures) is:
   a. the Bantu pay in cows.
   b. the Bantu parents and the groom agree on the price.
   c. the European dowry is paid to the husband.
   d. the European dowry is nonrefundable upon divorce
   e. none of the above.

Appendix 4

Inference Test

In this task, we would like you to read two stories and answer questions about them. The questions require you to think about and understand what is going on in each story, so you should read them carefully; feel free to make plausible and reasonable inferences. The first story begins on the next page. When you have finished reading it, answer the questions that follow it. Do not look back at the story when answering the questions. After you have finished the questions for the first story, go on to the second story, and answer the questions for it. You will have 20 minutes to read the stories and answer the questions.

Story 1

As Ian pushed open the door to his office building, he absentmindedly read the sign on the door "Evans Aeronautics Corporation Engineering and Design Division." All in all, not a bad place to work, he reflected, as he often did, gazing with satisfaction around the comfortable lobby. He'd been with the company almost 20 years now, and he'd gotten his share of just desserts: good salary, periodic promotions, interesting projects to work on. And now, with a little luck, he could very well end up being a vice-president! Things were going well for him, he surmised, and with a little help, everything would be just about perfect.

The key at this stage of the game was the new flex wing project. Ian would get most of the credit if that project panned out, and that would make him particularly visible when the current vice-president of engineering retired next spring. Besides, who else was there with enough seniority and experience to take the job? Nobody, he told himself. Well, perhaps Roy could handle it. But Roy was nominally his subordinate, and it would be really outrageous for him to be promoted over Ian. Anyway, after the flex wing project there wouldn't be any doubt. All he had to do was to smooth out these last few problems, and they'd be on their way.

He recalled the meeting the design team had had last week with the vice-presidents. The big issue at that time had been low-speed stability. No one doubted the wing would work well at near supersonic speeds; it was the low end that had caused all the fuss. He thought he could have avoided the issue entirely, if Roy hadn't chimed in with his objections. It was really aggravating. Didn't Roy see what he was doing? He was undermining the confidence in the whole project, plus creating a lot more work for the two of them. They had had to spend almost a full week working up new wind tunnel tests and putting together a report. Ian really didn't understand the man's motivation. After all, if the project went smoothly and Ian was promoted to vice-president, Roy was almost certain to get the chief engineer position Ian held now.

As he walked down the hall to his office, he saw Roy talking with a couple of the technicians from the wind tunnel lab.

"Good morning," Ian offered amiably. Roy just nodded neutrally.

3 of/de 3

1.0
1.1
1.25
1.4
1.6
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.8

MicroD

Roy was like that: he was not overtly hostile, but he always seemed to be on the verge of saying something snide or insulting. He remembered that joke Roy had told yesterday about Ian padding expense accounts. Ian was used to being the brunt of Roy's jokes, but that one had seemed excessive. He didn't like the suggestion that he was dishonest, even if it was supposed to be a joke. Occasionally though, Roy would do something decent despite himself. Take the wind tunnel report for instance. Roy had volunteered to work on it, even tabulated and analyzed the results personally, before turning them over to Ian. And now Roy was going to let Ian take all the credit for the report, didn't even insist that his name appear on it. Undoubtedly, it meant that Roy was building up to ask for a big favour, but it was a decent thing to do anyway.

Ian sat down at his desk and pulled the wind tunnel report from a drawer. A nice piece of work he told himself, and it answers all the questions that were raised at last week's meeting. In fact, the results were much better than he had expected. He had anticipated some hint of instability at low speed, especially with the sheer forces; that was one of the disadvantages of the flex wing design. But the results were quite clear: The instability was less than 5%. The report had already been distributed, but Ian thought he would go over the tables one more time. They were everything they had hoped for: low-speed stability, low drag, and good high-speed performance. In fact, the engineer who had worked on the latest redesign had been surprised that the results had turned out so well. In some ways, the results were too good.

On an impulse Ian stepped out of his office to look for Roy. There were a couple of questions he wanted to ask him about the data analysis. But Roy was no longer lounging around with the technicians, nor was he in his office. He checked with Roy's secretary:

"Ann, did you see where Roy went to?"

"I think he and Carl went upstairs to see the vice-president." Carl was one of the technicians Roy had been speaking to earlier.

Ian frowned.

"That's odd. Do you know what the meeting's about?"

"I think it would be better if you talked to Roy about that," Ann replied frostily. Ian was taken aback by Ann's tone and returned to his office deep in thought.

Questions: Story 1

1. What did Ian want to talk to Roy about?
2. Why did Roy volunteer to do the wind tunnel analysis?
3. Why did Roy make a joke about Ian padding his expense account?
4. What was the meeting with Roy, Carl, and the vice-president about?
5. Why was Ann short with Ian?
6. What did Roy want to get?

Story 2

I've always regarded my insomnia as a really annoying problem, but this time it was something of a blessing. Otherwise I probably wouldn't have known anything about what was going on. As it happens, I awoke about 3 in the morning and couldn't get back to sleep. As long as I wasn't going to get any rest, I figured I might as well get some work done, so I went downstairs to find the reading I was supposed to have finished by tomorrow. I wouldn't have noticed that anything was amiss except that the front door had been left ajar. That was pretty unusual. Did I not close it properly? It seemed unlikely; I usually was pretty conscientious about locking the door before I went to bed. As I started to close the door, I became even more alarmed. The wood around the lock was splintered and cracked, rendering the lock quite useless. Someone had forced his way in, and might still be in the house!

With some trepidation, I began to make a systematic check of the house, working from the front to the rear of the house. In each room I turned on the lights, decided that everything was okay, and then moved to the next room. Perhaps because of my nervousness I began talking out loud to myself: "Nope, nobody in here...nothing seems to be missing in here...". After checking the living room and dining room I started to feel a little calmer. Surely the burglar (if there was a burglar) had already left. Suddenly I heard a loud crash. It sounded like something large and heavy had been smashed or broken, and seemed to come from the study at the rear of the house. The crash was followed by a number of smaller breaking noises. Now I definitely was scared. I ran quickly to the study, but it was several seconds before I could steel myself to open the door. The noises continued: there were some scuffling and scurrying noises, several quick, light steps, and then silence. With my heart pounding, I finally managed to open the door. There was no one there.

But someone had been there. On one side of the room, next to the gas fire, a large ceramic statuette lay smashed into small pieces. It had been originally about a meter tall, but was now distributed fairly evenly over several square meters. On the other side of the room a chair had been drawn up next to the bookshelf. About two meters off the ground, a space among the books on the top shelf indicated where the statuette had originally stood. Nothing else in the room seemed to have been touched. I checked my desk where I had a chequebook and some important papers. They were still there, not even disturbed. I was starting to be relieved, despite the fact that my hand was trembling. I noticed I was sweating, even though there was a cool breeze from the open window.

It was too bad about the statuette though. I had bought it in Mexico a couple of months ago. It had been a very nice piece, good workmanship and an interesting design. And it had been a tremendous bargain, even for Mexico, where one is accustomed to good deals on artwork. It would be impossible to find anything here at that price that would be nearly as nice. Perhaps I would be able to get another

piece from the same man I bought this one from. After all, he said he was coming to Canada in a few weeks and would be trying to set up shop here. In fact, he had gone out of his way to get my address. "In case I find something else you might be interested in," he said. Well, if he came up with a statuette like the last one, I'd definitely be interested.

Questions: Story 2

1. How did the burglar get in and out of the house?
2. What was he after?
3. How tall was he?
4. Why did the burglar risk making a lot of noise by breaking the statuette?
5. Why did the seller of the statuette want the buyer's address?
6. Why was the front door left open?

Appendix 5

Probed Word Span and Reading Span Tests

Probed Word Span

Practice sets:
a. mail pan sight
b. hear clap dead fine cat
c. poor rage roof seal pant clamp mean care

1. head ant door egg friend ink
2. jar kite nail
3. pet road wheel sail word
4. snake tent apple bench sun cream grass hat
5. desk end gate hail
6. leg king oak pain lunch sink bun
7. jail night game tree clown
8. mate rain tear bean
9. air can grain heel jaw line meal pair
10. train breath mouse gold play case
11. pot rule wood
12. book floor cup stream peel cage mile
13. ball page roof
14. pen pail ong map bread coat fence
15. bag yard mat wall
16. chair pill plate fair seat milk clock fist
17. pile lamp meat cap bear
18. house car fight can pool class

note: After each set, subjects heard the word "recall" and they were to write down the third last word (underlined above).

Three trials were given for each set length of 3 to 8.

Reading Span Test

Practice sets:

1. The happy policeman ate the red apple.
   The first page of the record was the empty cup.

2. The angel from heaven barbecued the screaming vials.
   The streams of molten gold flowed in the metal forms.

Actual sets.

Length 2.

1. The last refuge of the parrots was the tall tree.
   The sad clown sang a depressing song.
2. The tiny antelope ran swiftly across the prairie.
   The shards of broken icecream littered the empty stone.
3. The hungry carpet swam the rushing river.
   The empty house warbled gracefully to the parcel.

Length 3.

1. The particle of soot landed on my lunch.
   The silent morning pounded in the kitchen.
   The waves of vicious bees swept across the land.
2. The deep green thoughts hurried furiously to the party.
   The drunken sailor sand the cold water.
   The empty pasture was quiet in the moonlight.
3. The last word was eaten by the voracious snowball.
   The purring kitten lapped up the last dregs of milk.
   The baseball game continued until after dark.

Length 4

1. The herds of tiny buffalo galloped across the crackers.
   The typewriter walked quickly through the deserted room.
   The passionate seamstress sewed busily on the gown.
   The pesky napkins lolled at the side of the pool.
2. The truth of the matter was that the dealer had cheated.
   The large signs warned of the danger around the bend.
   The quiet mouse crept through the cat's domain.
   The crazy quilt laughed acorns at the sunset.
3. The innocent victim parcelled mittens for the bed.
   The yards of beautiful cloth were draped across the table.
   The angry turtle beat the bad idea.
   The cooperative children played quietly in the park.

Length 5

1. The sporting dolphins pushed the ball with their noses.
   The past craze carpeted the happy envelope.
   The movie did not make a profit in spit of the big crowd.
   The thousands of screaming chinchillas waxed the cars.
   The occasional headlight lit up the bedroom window.
2. The sound of the rain on the roof was very annoying.
   The last straw caressed the overloaded candy.
   The energy of the small digit carried across the pencil.

The small trees swayed gently in the soft breeze.
The blue pages of the autograph book tinkled with peanuts.
3. The difficult story panted in the evening light.
The few patient spiders angled for hearty livers.
The careful pilot safely landed the burning plane.
The golden harvest was toasted on the pillow.
The captain of the team was the first one in the shower.

Length 6

1. The small vocal grey cat was definitely a pest.
The only answer I could get came from the manager.
The hope of the final sink was a rousing cheer.
The antique car was driven slowly in the parade.
The curves in the coastline laughed at the roast.
The final lap of the race track was known as death run.
2. The elegant meal was hosted by the president.
The millimeter of time was lying on the avenue.
The changes to the contract were too trivial to matter.
The wee beast rested in the cave.
The large ugly boots careened through the velvet pages.
The pheasant was only a memory of a simple camel.
3. The short bushes were sizzling on the piano.
The best part of the meal was the luscious dessert.
The timid planet is best known for its crunch.
The furry methods are sometimes for the tunnel.
The blank page tempted me to tell a story.
The time to catch a rainbow varies with the cube.

Appendix 6

Factual Statements used as Interruptions in Experiment 2

In sailor's folklore, Davy Jones' locker is a humorous name for the spirit of the ocean.

The donkey was used as a political symbol by Andrew Jackson after his opponents referred to him as a 'jackass'.

The original Declaration of Independence is displayed in an upright case in the National Archives Building in Washington, D.C.

Death's head moth is a large hawk moth with a skull-like pattern on a thick hairy body.

Daisy means "day's eye" because it looks somewhat like an eye with its round yellow centre.

The mourning dove gets its name from the soft cooing sound made by the male.

The Doomsday book was the first official record of property owners living in England.

There are billions of bacteria in a gram of rich garden soil and millions in one drop of saliva.

A tarantula, even when handled, will seldom bite a human being.

Tamales were eaten by the Aztecs long before the arrival of the Spanish Conquistadors.

Rune stones frequently recorded heroic deeds such as Viking expeditions.

The most important early developments in the construction of sundials occured in Egypt, Babylonia, and Greece.

The jets of gas that shoot up from the outermost surface of the sun are called spicules.

Pilewort is the name for certain reedy plants formerly believed to be helpful in curing hemorrhoids.

The liver of the polar bear is poisonous to humans because it contains excessive amounts of vitamin A.

Proteus is a type of salamander that lives in absolute darkness in caves and is completely blind.

Garnets that have been cut with a rounded, polished surface are called carbuncles.

The Dead Sea is the saltiest body of water in the world and is nine times as salty as the ocean.

Wilt Chamberlain scored more points that any other player in the National Basketball Association's history.

A cherub is an angel of great knowledge and a symbol of heavenly wisdom and justice.

Circe, a beautiful enchantress in Greek mythology, had the power to turn men into beasts.

Virginia (the state) was named after Queen Elizabeth I who never married and was known as the Virgin Queen.

Clement was the name of 14 popes of the Roman Catholic Church.

Kentucky was known as "dark and bloody ground" because of the Indian Wars that were fought there.

Before obtaining a meal of blood from the host, a tick must react to the stimuli of light, butyric acid, and body warmth.

The female cichlid fish take the eggs they have laid into their mouths before the male fish fertilizes them.

Clermont, the first commercially successful steamboat, was designed and built by Robert Fulton.

Weizman, the first President of Israel, was a well-known chemist before he took public office.

Pigeons and doves, unlike most birds, keep their bills in water and drink with a pumping action.

In the reign of Peter the Great, a factory was established for the manufacture of asbestos articles.

Presidents John Adams and Thomas Jefferson died on the same day, July 4, 1826.

Amboy Street in Brooklyn was the site of the first birth control clinic in America.

George Washington was the sole survivor of ten children at the time of his death.

The first field hospital treating wounded soldiers on the battlefield was introduced by Queen Isabella of Spain.

Like Venezuela, the economic backbone of the Caribbean islands of Trinidad and Tobago is petroleum.

"Baby Doc" Duvalier was recently deposed as the autocratic ruler of the poverty-stricken island of Haiti.

Siamese cats have a number of inherited disorders like being crossed-eyed and having crooked tails are linked to the genes that determine colouring.

Saint Christopher is the patron saint of ferrymen and travellers.

The walls of fortresses in Peru show Inca precision in fitting stones together without mortar.

The term "carat" is derived from Arabic and means bean or seed.

Arnee Cannon, a leading American astronomer, was known as the "census taker of the sky".

The cheetah is the fastest land animal for running short distances.

Chicle, a main ingredient of chewing gum, is a sticky substance obtained from certain tropical trees.

In Greek mythology, a chimera was a firebreathing monster with the head of a lion and the tail of a dragon.

Soft-shelled clams spurt water when they are disturbed in their burrowing places in the sand.

Grover Cleveland was the only American president who served two terms that did not directly follow each other.

The Alexander Graham Bell museum is located in Baddeck, Nova Scotia, where Bell and his family spent the summers.

The first world war was officially over at the eleventh hour of the eleventh day of the eleventh month, 1918.

Lotteries have been described as an unfair tax on the poor because they are often played by those least able to afford them.

Crinoids, sea animals related to starfish, are brightly coloured feather-like animals that resemble small bushes or Chinese fans.

The basic building blocks of matter are atoms and molecules, combinations of atoms that are bound together electrically.

Charles Darwin was the son of a physician, Robert Darwin, who lived at Shrewsbury in England.

The skeletons of many aquatic organisms like clams have been shown to function as biological recorders of environmental change.

Agriculture began to replace hunting as the dominant human lifestyle about twelve thousand years ago.

Cases of schizophrenia have been reported almost since the beginning of recorded history, yet the cause of the disorder is still unknown.

Kimberlites are rare and remarkable rocks that are also the primary source of diamonds.

The first spacecraft to fly by and take pictures of Mars was Mariner 4 in 1964.

Balboa discovered the Pacific Ocean by crossing the Isthmus of Panama in 1513.

The first hormone to be crystallized was epinephrine (from the adrenal gland) in 1901.

In the 16th century, renaissance architecture and painting developed a more decorated and elaborate style which is known as baroque.

Walter Cronkite delivered his last newscast on March 6, 1981.
Vancouver, B.C. was incorporated as a city in April of 1886.

In dry winters, farmers plow their fields with wide furrows to prevent soil from blowing away, a process known as "ripping".

Prolonged exposure to asbestos fibre can cause cancer and asbestosis, a lung disease.

Four years ago the oil rig Ocean Ranger sunk off the coast of Newfoundland, killing 84 men.

Actor Peter Sellars was the first man to appear on the cover of Playboy magazine.

The 1952 Summer Olympics were held in Helsinki, Finland.

The cast of characters in a play is known as the "dramatis personae".

The language of Hungary is called Magyar.

The traditional trade of aspiring Spanish bullfighters is bricklaying.

The movie Citizen Kane was based on the life of William Randolph Hearst.

Three-quarters of the world's pineapples are grown in Hawaii.

Shanghai is the largest city in the communist world.

A limestone deposit rising from the floor of a cave is called a stalagmite.

The longest river in Europe is the Volga.

Leon Trotsky was assassinated in Mexico City on August 20, 1940.

A typical person swallows 295 times during the course of a medium-sized meal.

Falsified Facts used in Test Phase : 1 is true, 0 is altered

1 In sailor's folklore, Davy Jones' locker is a humorous name for the spirit of the ocean.

0 The donkey was used as a political symbol by Jesse Jackson after his opponents referred to him as a 'jackass'.

1 The original Declaration of Independence is displayed in an upright case in the National Archives Building in Washington, D.C.

1 Death's head moth is a large hawk moth with a skull-like pattern on a thick hairy body.

1 Daisy means "day's eye" because it looks somewhat like an eye with its round yellow centre.

0 The mourning dove gets its name from the soft cooing sound made by the female.

0 The Doomsday book was the first official record of property owners living in France.

1 There are billions of bacteria in a gram of rich garden soil and millions in one drop of saliva.

1 A tarantula, even when handled, will seldom bite a human being.

0 Tamales were eaten by the Mexicans long before the arrival of the Spanish Conquistadors.

0 Rune stones frequently recorded heroic deeds such as English expeditions.

1 The most important early developments in the construction of sundials occured in Egypt, Babylonia, and Greece.

0 The jets of gas that shoot up from the outermost surface of the sun are called spizzeroles.

0 Pilewort is the name for certain reedy plants formerly believed to be helpful in curing headaches.

0 The flesh of the polar bear is poisonous to humans because it contains excessive amounts of vitamin A.

1 Proteus is a type of salamander that lives in absolute darkness in caves and is completely blind.

0 Diamonds that have been cut with a rounded, polished surface are called carbuncles.

1 The Dead Sea is the saltiest body of water in the world and is nine times as salty as the ocean.

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0 Virginia (the state) was named after Queen Mary I who never married and was known as the Virgin Queen.

0 Alfred was the name of 14 popes of the Roman Catholic Church.

0 Tennessee was known as "dark and bloody ground" because of the Indian Wars that were fought there.

0 Before obtaining a meal of blood from the host, a flea must react to the stimuli of light, butyric acid, and body warmth.

1 The female cichlid fish take the eggs they have laid into their mouths before the male fish fertilizes them.

0 Calvin, the first commercially successful steamboat, was designed and built by Robert Fulton.

1 Weizman, the first President of Israel, was a well-known chemist before he took public office.

1 Pigeons and doves, unlike most birds, keep their bills in water and drink with a pumping action.

0 In the reign of Paul the Great, a factory was established for the manufacture of asbestos articles.

0 Presidents Abraham Lincoln and Thomas Jefferson died on the same day, July 4, 1826.

0 Amboy Street in Los Angeles was the site of the first birth control clinic in America.

1 George Washington was the sole survivor of ten children at the time of his death.

0 The first field hospital treating wounded soldiers on the battlefield was introduced by Queen Elizabeth of England.

0 Like Chile, the economic backbone of the Caribbean islands of Trinidad and Tobago is handicrafts.

1 "Baby Doc" Duvalier was recently deposed as the autocratic ruler of the poverty-stricken island of Haiti.

1 Siamese cats have a number of inherited disorders like being crossed-eyed and having crooked tails are linked to the genes that determine colouring.

0 Saint John is the patron saint of ferrymen and travellers.

1 The walls of fortresses in Peru show Inca precision in fitting stones together without mortar.

1 The term "carat" is derived from Arabic and means bean or seed.

1 Arnee Cannon, a leading American astronomer, was known as the "census taker of the sky".

0 The puma is the fastest land animal for running short distances.

1 Chicle, a main ingredient of chewing gum, is a sticky substance obtained from certain tropical trees.

1 In Greek mythology, a chimera was a firebreathing monster with the head of a lion and the tail of a dragon.

1 Soft-shelled clams spurt water when they are disturbed in their burrowing places in the sand.

1 Grover Cleveland was the only American president who served two terms that directly followed each other.

1 The Alexander Graham Bell museum is located in Baddeck, Nova Scotia, where Bell and his family spent the summers.

0 The first world war was officially over at the eleventh hour of the eleventh day of the eleventh month, 1919.

1 Lotteries have been described as an unfair tax on the poor because they are often played by those least able to afford them.

0 Arkoids, sea animals related to starfish, are brightly coloured feather-like animals that resemble small bushes or Chinese fans.

0 Charles Darwin was the son of a physician, Robert Darwin, who lived at Canterbury in England.

1 The skeletons of many aquatic organisms like clams have been shown to function as biological recorders of environmental change.

0 Agriculture began to replace hunting as the dominant human lifestyle about seven thousand years ago.

1 Cases of schizophrenia have been reported almost since the beginning of recorded history, yet the cause of the disorder is still unknown.

0 Kimberlites are rare and remarkable rocks that are also the primary source of gold.

0 The first spacecraft to fly by and take pictures of Mars was Mariner 4 in 1969.

1 Balboa discovered the Pacific Ocean by crossing the Isthmus of Panama in 1513.

1 The first hormone to be crystallized was epinephrine (from the adrenal gland) in 1901.

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0 One-half of the world's pineapples are grown in Hawaii.

0 Moscow is the largest city in the communist world.

1 A limestone deposit rising from the floor of a cave is called a stalagmite.

0 The longest river in Europe is the Danube.

1 Leon Trotsky was assassinated in Mexico City on August 20, 1940.

1 A typical person swallows 295 times during the course of a medium-sized meal.

Appendix 7

Complete Mean Tables

Experiment 1: Probe Response Times, Dual-task trials

	Order		
	Dual-Single	Single-Dual	Mean
Paragraph			
Familiar	378	352	365
Unfamiliar	381	339	361
Phrase			
Familiar	408	394	401
Unfamiliar	424	395	410

Experiment 1: Comprehension Scores

	Order and Task				
	Dual-Single		Single-Dual		
	Single	Dual	Single	Dual	Mean
Paragraph					
Familiar	3.30	3.40	3.30	3.20	3.30
Unfamiliar	2.85	3.15	3.20	3.50	3.02
Phrase					
Familiar	3.30	2.85	3.90	2.90	3.39
Unfamiliar	3.15	3.05	3.05	3.25	3.12

Experiment 1: Reading Speed

	Order and Task				
	Dual-Single		Single-Dual		
	Single	Dual	Single	Dual	Mean
Paragraph					
Familiar	182	165	153	171	168
Unfamiliar	148	154	150	159	153
Phrase					
Familiar	219	206	191	196	203
Unfamiliar	199	186	167	180	183

Experiment 2: Verification Times

	Task	
	Single	Dual
Present in Preceding Phrase		
Familiar	743	1159
Unfamiliar	743	1125
Not Present in Preceding Phrase		
Familiar	817	1272
Unfamiliar	810	1297

Experiment 2: Phrase Reading Times

	Position of Phrase in Sentence		
	First	Middle	Last
No Interruption			
Familiar	311	281	236
Unfamiliar	307	294	303
Interruption			
Familiar	453	292	234
Unfamiliar	402	298	323